No. 5. New Series. January 1878. [2s. 6d.

THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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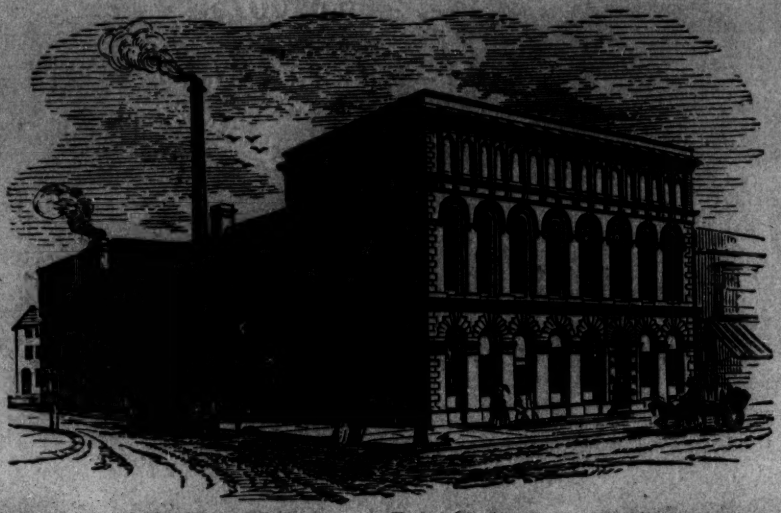

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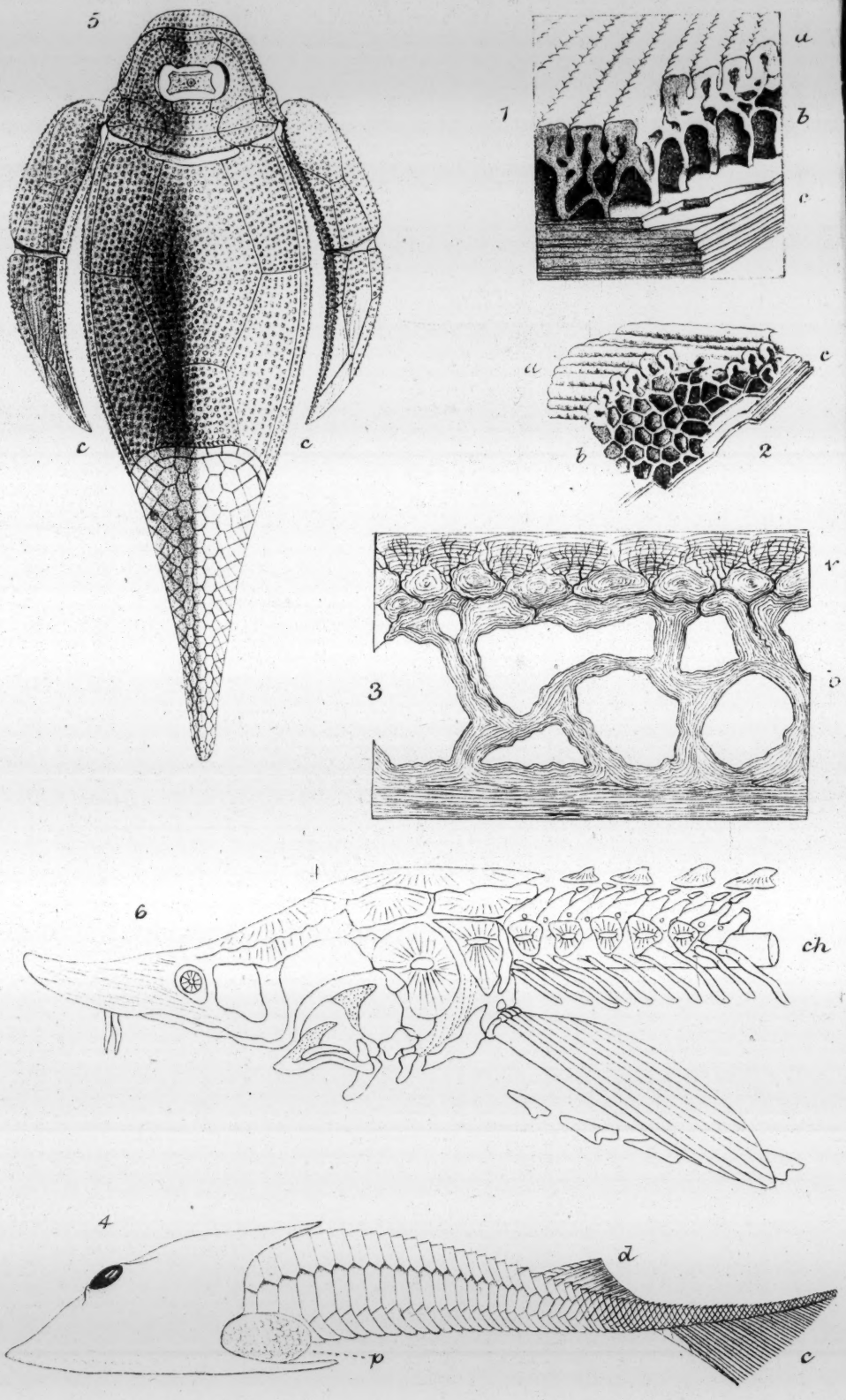

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POPULAR SCIENCE REVIEW.

ON SOME ARMOURED FISHES.

By HENRY WOODWARD, F.R.S., F.G.S.

[PLATES I. AND II.]

THE doctrine of "evolution," or the tendency among animals to produce variations, which under certain conditions may survive or even supplant the parent-form, has attracted so much attention of late, that it may not be without interest to glance at some of the first representatives of the Vertebrate sub-kingdom, whose remains are left to us in the older rocks, in order to ascertain whether Palæontology affords any evidence which may be of service in elucidating this most interesting subject.

And here at the outset, it must be confessed that the oft-pleaded imperfection of the geological record leaves much untold which the naturalist seeks to discover.

Taking the class of Fishes as the earliest representatives of the Vertebrata, we naturally hope to find evidence of the first and simplest forms preserved to us in a fossil state; but the researches of the zoologist have brought to light a form now living which, from the perishable nature of its entire organism, we can never hope to find fossil; and comparative anatomy shows us that the ordinarily received notion of a vertebrate animal being one which possesses a backbone, frequently fails us from the apparent absence of this most important part!

For example, we have in the anomalous *Amphioxus* or "Lancelet" (Woodcut, Fig. 1) an animal placed with the Vertebrata, yet of the most elementary construction conceivable. Indeed, it seems paradoxical to class such a creature with vertebrate animals, seeing that it has *no skeleton*, properly so called; the bony centra of the vertebral column are represented by a

semigelatinous rod (*ch*) (the "notochord," or *chorda dorsalis* of embryologists), enclosed in a membranous sheath (*n*) supporting the spinal cord (*md*).

FIG. 1.

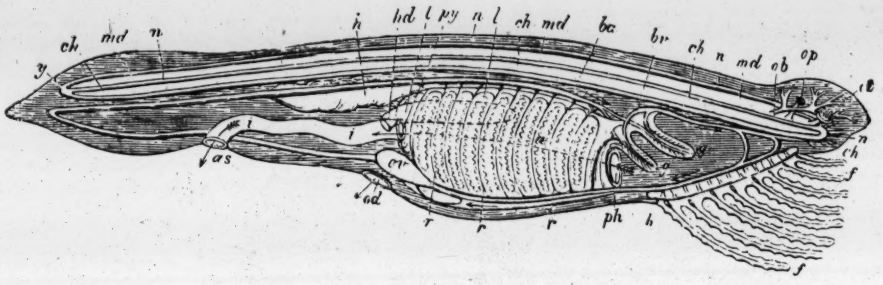


DIAGRAM OF THE ANATOMY OF THE "LANCELET," *Amphioxus*, OR *Branchiostoma* (after Owen).*

There is no skull, and the spinal cord does not expand in front to form a distinct brain or *cerebrum*. The body is lanceolate in shape, and is provided with a narrow membranous border, of the nature of a median fin, which runs along the whole of the dorsal and a portion of the ventral surface, and expands at the tail to form a lancet-shaped caudal fin. No true "paired" fins representing fore and hind limbs exist. The mouth (*b*) is a longitudinal slit, placed at the front of the head, entirely destitute of jaws, but surrounded by a number of oral cirri (*f*, *f*), which are borne by a pair of jointed cartilaginous filaments. The throat is provided with several leaf-like filaments (*g*, *g*), which are richly supplied with blood, and appear in part to discharge the function of gills. The mouth opens into a dilated chamber, termed the pharyngeal or branchial sac (*ph*).

The walls of this chamber are strengthened by numerous cartilaginous filaments (*r*, *r*, *r*), between which are transverse slits (*æ*) or clefts, not opening upon the skin, and the whole chamber is lined with a richly ciliated mucous membrane.

The water admitted by the mouth passes through the branchial clefts into the abdominal cavity, and escapes through the aperture (*as*) in the ventral surface. The alimentary canal (*i*, *i*) proceeds from the posterior end of the branchial sac; it has a sac-like organ (*h*) appended to it, which probably represents the liver.

* We are indebted to the courtesy of Messrs. Longmans & Co. for permission to use this woodcut, and also for Fig. 2, from Prof. Owen's "Comparative Anatomy, Vertebrates," Vol. I., 1866, p. 31, fig. 23, and p. 26, fig. 16.

Letters in woodcut, Fig. 1, not referred to in the text:—

ob. longitudinal filamentary ligament supporting the spinal chord; *y.* posterior termination of notochord; *bv.* branchial vein; *ba.* branchial artery; *ov.* ovarian vessel? *od.* ovarian duct? *h.* the liver? *hd.* hepatic duct; *py.* pylorus.

There is no swim-bladder, no special heart, the circulation being effected by means of several contractile dilatations—"pulsatile portal sinuses" (Owen)—developed upon the main blood-vessels. The blood is colourless. A pair of nerves are given off to the eyes (*op*), and another branch to a ciliated pit, probably an olfactory organ (*ol*).

The resemblance between the respiratory pharyngeal sac of the "lancelet" and that of the tunicated mollusks, Ascidians, or "sea-squirts," was pointed out by the late Professor Goodsir,* who also considered the "Lancelet" as allied to the Annulosa, from the simple organization of its respiratory and circulatory system.

In the more recent researches of M. Kowalevsky, he traces a close affinity between *Amphioxus* and the early stages of some Ascidians.

"Thus in *Amphioxus* are united characters belonging to the Tunicata and Annelida, and unexpected relations are revealed between the Vertebrata and Invertebrata." †

Yet even if we might consider *Amphioxus* to be, like *Ammocœtes*, an immature form, which perhaps reached a somewhat higher adult stage by a tardy metamorphosis,‡ there are many other animals besides the "Lancelet" in which the skeleton in the adult retains many of its embryonic characters, and although these are restricted at the present day to a few among the living orders of fishes, such characters were common to all the older fossil forms.

Professor Owen observes "the centrum is the most constant vertebral element as to its existence, *but not as to its ossification*. There are some living fishes, and formerly there were many, now extinct, in which the peripheral elements of the vertebra become ossified, the central one remains unossified."§

This central basis of the neuro-skeleton, as we have already seen in the case of *Amphioxus*, may attain in the adult animal to no higher condition than that in which it is laid down in the embryo of every vertebrate animal, namely, as a more or less cylindrical fibrous sheath, filled with simple cells containing jelly. In the Lamprey (*Petromyzon marinus*) cartilaginous processes strengthen the sides of the neural canal. In the Sturgeon (*Acipenser sturio*) the inner layer of the notochord has assumed the texture of tough hyaline cartilage, whilst

* "Trans. Roy. Soc. Edinb." Vol. xv. p. 259, Plate xi.

† "On Certain Genera of Living Fishes and their Fossil Affinities." By Miss Agnes Crane. "Geol. Mag." 1877, Vol. iv. p. 209.

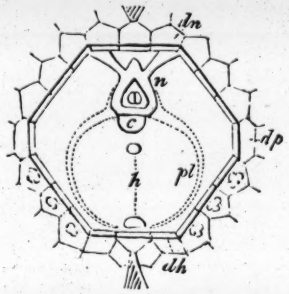
‡ *Ammocœtes*, after the third year from the egg, passes by metamorphosis to *Petromyzon*. (Owen, "Comp. Anat. Verteb." Vol. i. 1866, p. 7.) Save that *Ammocœtes* inhabits mudbanks in rivers, whilst *Amphioxus* burrows in sand beneath the sea, these forms agree closely with each other.

§ Owen, "Comp. Anat. Verteb." Vol. i. 1856, p. 30.

neural and hæmal processes of firm opaque cartilage are also present.

This absence of a solid vertebral column and bony framework does not, however, necessarily imply a poverty of lime in such animals, for many fishes in which the notochord is unossified have well-developed neural and hæmal processes, or have their heads and bodies more or less encased in stout bony plates, forming a powerful defensive armature. (See Pl. II., Fig. 1, *Coccosteus*.) Indeed, bony matter may be variously disposed in the bodies of vertebrate animals.

FIG. 2.



SEGMENT OF NEURO- AND DERMO-SKELETONS OF *Ostracion bicaudalis* (after Owen).

dn, *dp*, *dh*. dermal plates.
n. neurapophyses.
pl. pleurapophyses.

The "Trunk-fish" (*Ostracion bicaudalis*, Pl. II., Fig. 3), the Tortoise, and the Armadillo, are instances of its accumulation upon or near the surface of the body, constituting the "dermo-skeleton;" the deep-seated bones in relation to the bony-framework forming the "neuro-skeleton," being also present in these and many other instances. (See Woodcut, Fig. 2.)

It is important, however, not to confound this dermo-skeleton in the Vertebrata with the exo-skeleton in the Invertebrata.

The shells and crusts of molluscous and crustaceous animals are *unvascular*; they grow by the addition of layers to their circumference, they may be cast off when too small for the growing body, and be reproduced of a larger size. When fractured, the broken parts may be cemented together with fresh shell-substance, but are not unitable by the action of the fractured surfaces from within.

Bone, on the contrary, is a living vascular part, growing by internal molecular addition and change, and having the power of repairing fracture or other injury (Owen).

It may seem somewhat needless to recall to mind these elementary details; but in speaking of the earliest known fossil Vertebrata, it must be borne in mind that in many instances they are represented only by remains of their dermo-skeletons, the microscopic structure of which is frequently all that can be definitely relied upon to class them with the Vertebrata.

To the late Sir Roderick Murchison is due the honour of having, in company with Mr. Hugh Strickland, first discovered, in 1837, two thin "bone-beds," each little more than one inch thick, and separated by about fifteen feet of fossiliferous Upper Ludlow rock in a cutting of the Gloucester and Ross railroad. Although several of the supposed fish-remains from the

"Ludlow-bone-bed"—originally described by Agassiz—have now been referred, by M'Coy, Salter, and myself, to the class Crustacea, there are a sufficient number of true ichthyic fragmentary-remains left, justly to entitle this bed to retain its primitive name.

Many of the early discoveries of fish-remains, however, have to be cancelled. For example, "the defensive spine of *Onchus*," announced in 1847 as detected in the Baia limestone by the geologists of the Government Survey; and in the same year, from the upper part of the Llandeilo Flags, by Professor Sedgwick, are only the tail-spines of a large species of "Pod-shrimp," *Ceratiocaris*, a bivalved phyllopodous crustacean, nearly related to the living *Nebalia*, but immensely larger in size. The same explanation must be applied to Professor Phillips's "*Onchus* spines" from the Wenlock shale, and Sedgwick's fish-remains from the Wenlock limestone; whilst the *Sphagodus pristodontus* of Agassiz proves to be only a part of the foot-jaw of *Pterygotus*.

As a set-off against these fossil crustaceans having been spuriously elevated to the rank of fishes, it is not without interest to find that for 17 years the discovery of fish-remains of the genera *Scaphaspis* and *Cephalaspis* in Cornwall and South Devon was precluded from recognition by the decision of Professor M'Coy, who determined them to be *sponges!* belonging to the genus *Steganodictyum*.*

A similar incorrect diagnosis led Professors Römer and Kner to refer the Cephalaspidean head-shields, from the Lower Devonian of the Eifel and of Russian Gallicia, to the genus *Archæoteuthis* among the fossil cuttle-fishes. They are now placed by Lankester in the genus *Scaphaspis*; *Sc. dunensis* of the Eifel being quite closely related to *Sc. cornubicus*, from Mudstone Bay, South Devon; whilst *Scaphaspis Kneri* is undistinguishable from *Scaphaspis Lloydii*, from Herefordshire (Lankester).

A revision of the Cephalaspidean Fishes at the present time, presents us with 15 genera and about 53 species, some three of which are, however, doubtful.

To Mr. John Edward Lee, F.G.S., of Torquay, belongs the honour of the discovery (in 1859) of the earliest known head-shield of a fish in the Lower Ludlow beds of Church Hill, Leintwardine, Shropshire. This, the oldest known vertebrate

* Mr. Pengelly states that he has upwards of 300 fragments of *Pteraspides* from the Devonian rocks of Mudstone Bay, South Devon, which have lain in his cabinet for years, having been formerly supposed to be sponges. Yet, before 1848, Mr. Peach, the veteran geologist, had announced the discovery of fish-remains in Cornwall, in the "Trans. Roy. Geol. Soc. of Cornwall," being the identical fossils which, in 1851, Prof. McCoy called *Steganodictyum*, and referred to the Amorphozoa.

animal of which traces have been met with, is represented only by a very few imperfect specimens. It was described by the late Mr. J. W. Salter, F.G.S., in 1859 ("Annals and Mag. Nat. Hist.," Vol. IV., p. 45), and more fully in Professor Lankester's Monograph on the "Fishes of the Old Red Sandstone" (Part I., 1867, p. 25, part II., fig. 4, "Mon. Pal. Soc.," Vol. XXI.).

FIG. 3.*

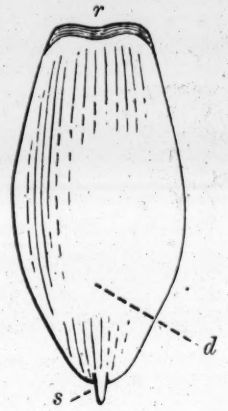


DIAGRAM OF THE SHIELD OF *Scaphaspis* (after Lankester).

r. rostrum, or rostral region.
d. central disc, or discal region.
s. posterior spine.

It belongs to the Pteraspidean division of fish-shields (for which the term *Heterostraci*† has been proposed by Professor Lankester), and to that simplest type the genus *Scaphaspis* (Woodcut, Fig. 3), in which the shield is of an oval form, and composed of a single piece about one inch and a half in length, resembling a much elongated ellipse, truncated at both ends. There is a small spine, or tubercle, near the posterior margin of the shield, the outer surface of which is marked by coarse longitudinal striæ. It is a very remarkable fact that not a trace of "osseous lacunæ" have been detected in the heterostracous head-shields. Externally, the surface, when well preserved, is covered with minute grooves and ridges, running parallel to, and concentrically with, one another. These surface-markings (Pl. I., Fig. 1, *a*) may not unfittingly be compared to the markings of the epidermis on the palms of the hands and fingers in man and other Primates. The inner surface of the shield is quite smooth and polished, and exhibits no vascular channels, as in *Cephalaspis*, only a few irregular ridges diverging from the centre of the shield, or running parallel to the margin.

Professor Huxley has minutely described and illustrated the microscopic structure of this oldest-known type of Fishes.‡ The shield is composed of three layers, the outer or "striated" layer (Pl. I., Figs. 1 and 2, *a*, *a*), the middle or "cancellated" (*ib.* *b*, *b*), the inner or "nacreous" layer (*ib.* *c*, *c*). This inner nacreous layer is made up of laminæ of about $\frac{1}{4300}$th of an inch, arranged horizontally, and is totally devoid of vascular

* For the use of this and nine other illustrations of the genera of Cephalaspidean Fishes in this paper, the author is indebted to the kindness of the Rev. T. Wiltshire, Sec. G. S., Hon. Sec. Pal. Soc.; they illustrate Prof. Lankester's Monograph in the Vols. of the Pal. Soc. for 1867 and 1869.

† From ἕτερος of another kind, and ὄστρακον a shell or dermal bone.

‡ "Quart. Journ. Geol. Soc." 1858, Vol. xiv. p. 267. Plates xiv. and xv.

canals or tubules, save where a canal of some size passes from its aperture upwards into the walls of the next layer.

In some cases these canals appear to open from the polygonal cavities of the middle layer; in other cases, they come directly from their apertures on the inner surface of the shield. In the upper wall of the stratum of polygonal cavities, the canals take a horizontal direction, still very few in number, and of large size, receiving here branches from the cavities. The calcareous laminæ are here arranged horizontally. If the section has been made transverse to the surface ridges, these appear as so many papilliform processes; or if along one of the ridges, a continuous horizontal layer is exhibited. Into this layer, or into these papillæ, the horizontal canals send short branches (one to each papilla), which give off minute tubules in every direction; these arborescent tufts (Pl. I., Fig. 3, *r*) correspond to the vascular bushes seen, under the microscope, in the external layer of *Cephalaspis*. The laminated material is arranged round these tufts concentrically, the finer branches traversing it much in the same way as dentinal tubules traverse dentine. Indeed, each of the sections of the ridges recalls very strongly the structure of a tooth, or of a dermal defence of a placoid fish. There is no trace of a "ganoin" layer beyond the laminated material forming the ridges; nor can any such layer be detected with the microscope.

The characteristic structure of these shields appears to be—the absence of bone-lacunæ, the paucity of vascular canals, and the excavation of the mid layer of the shield into large vascular sinuses (Pl. I., Figs. 1-3, *b*). It was the exposure of the inner "cancellated" layer, by the decortication of the outer "striated layer," which led Professors Kner and Römer to regard the pteraspidean shields from Russian Gallicia and from the Eifel as the remains of cuttle-bones.

After his examination of the structure of *Pteraspis*, Professor Huxley remarks*:—"No one can, I think, hesitate in placing *Pteraspis* among Fishes. So far from its structure having 'no parallel among fishes,' it has absolutely no parallel in any other division of the animal kingdom. I have never seen any molluscan or crustacean structure with which it could be for a moment confounded."

It must be borne in mind, in connection with this question, that no indication whatever of an internal bony skeleton, belonging to these fishes, has been found; and although in the other division, the *Osteostraci*†—represented by the genus

* "Quart. Journ. Geol. Soc." 1858, Vol. xiv. p. 277.

† From ὀστέον bone, and ὄστρακον a shell or dermal bone; because in this division the shell displays true bone-lacunæ as well as vascular tubuli.

Cephalaspis—we shall see that specimens have been found showing the entire body, they prove, though only by negative evidence, that such a structure did not exist.

This oldest form of fish is widely spread; specimens of *Scaphaspis* having been obtained from Upper Silurian and Lowest Devonian rocks in Gallicia, Russia; from the Lower Devonian, Eifel; from the Lower Devonian, Mudstone Bay, S. Devon; from Polperro, Cornwall; from the Lower and Upper Ludlow, the Downton sandstone, and the Lower Old Red Sandstone of Worcester, Hereford, and Shropshire; and from the Old Red of Forfarshire, Scotland. In all seven species have been described and figured.

FIG. 4.

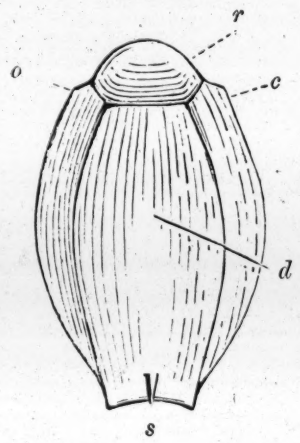


DIAGRAM OF THE SHIELD OF *Cyathaspis* (after Lankester).

o. orbits. *c.* cornua. *d. r. s.* as in Fig. 3 of *Scaphaspis*.

FIG. 5.

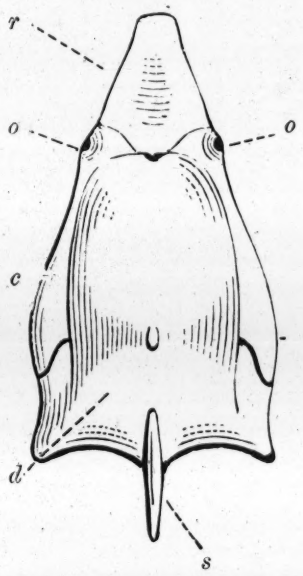


DIAGRAM OF THE SHIELD OF *Pteraspis* (after Lankester).

(Letters as in Figs. 3 and 4).

Although the shield in *Cyathaspis* (Woodcut, Fig. 4), is as simple in outline as in *Scaphaspis*, yet it betrays a tendency towards a more complex structure, being divided by sutures into a frontal or "rostral" portion, two lateral pieces (called "cornua") and a central or "discal" region. It is represented by two species only, from the Downton sandstone, and the Lower Old Red (or "Cornstones") of Herefordshire.

A new genus, named *Holaspis*, represented by a head-shield without sutures, from the Lower Old Red ("Cornstones") of Abergavenny, Monmouthshire, has lately been described and figured,* but although considered by Professor Lankester to be

* "Geol. Mag." 1873, vol. x. p. 241, plate x.

near to *Scaphaspis*, its outline and profile* are more like those of *Pteraspis*.

Pteraspis (Woodcut, Fig. 5), is the last and most highly developed of the Heterostracous fish-shields.

The shield is much more pointed than the other forms, resembling a javelin-head in shape, and is divisible by sutures into seven parts. The dorsal spine is strongly developed, and the small marginal orbits (*o*, *o*,) are distinctly visible. The palm-like wrinklings upon the surface are not unfrequently beautifully preserved.

Pteraspis has only three species, but they are found in Monmouthshire, in Shropshire, at Malvern, Worcestershire, in Herefordshire, and in Forfarshire, Scotland; all in the Lower Old Red Sandstone formation.

Professor Schmidt, of St. Petersburg, has described another Russian form, under the name of the *Trematáspis*, but we have not yet seen its figure or description.

Of the Osteostracous forms of head-shields that best known to palæontologists is the genus *Cephalaspis* (Pl. I., Fig. 4), established by Agassiz in his great work in 1835.† In this genus the posterior angles of the shield-shaped helmet are produced backwards in a pointed form, giving to the head the outline of a "saddler's knife"—"a tool with a crescent-shaped blade, and the handle fixed tranversely in its concave side. In general outline the *Cephalaspis* resembled this tool, the crescent-shaped blade representing the head, the transverse handle, the body. The head compared with the body was of great size, comprising nearly one-third of the creature's entire length. In the centre, and placed closely together, as in many of the flat fishes, were the eyes."‡ The fins consisted of two pectoral fins of very peculiar form and character (Pl. I., Fig. 4, *p*), a dorsal fin (*d*), placed very far back on the body, and a caudal fin, the rays of which are all placed inferiorly to the extremity of the body (*c*).

The pectoral fins have no trace of fin-rays or scales: they are simply ellipsoidal expanses, with some calcareous matter in their structure which has caused their preservation.

The body, which was triangular in form, was protected by four principal rows of imbricated rhomboidal scales, with a lower marginal row and probably eight rows of small ventral scales; the bony structure of these scales accords with that of the head-shield. The scales break up, and become smaller and much

* "Geol. Mag." 1873, Vol. x. p. 331 (woodcut).

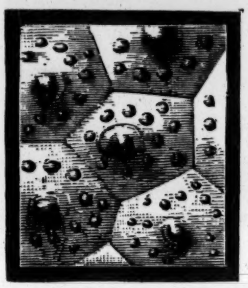
† "Poissons Fossiles du Vieux Grès Rouge, ou Système Dévonien: Neufchâtel." Folio plates, 4to. text; Vol. ii. 1835, p. 149.

‡ Hugh Miller, "The Old Red Sandstone," 1847, p. 172.

more numerous as they reach the dorsal fin, and recede thence to the slender extremity of the body.

"In but few of the specimens," writes Professor Huxley,* "which I have had the opportunity of observing, has the external surface of the cephalic shield been well exhibited, or preserved over any considerable surface. Where best shown it is somewhat uneven, and presents that curious apparent division into polygonal (usually hexagonal) areæ which has been described by Professor Agassiz (Woodcut, Fig. 6). On examining the apparent sutures closely, however, they have not presented to my observation precisely the appearance figured by him. They appear rather as if short, delicate, reddish brown lines had been ruled across the line of junction of the sides of the hexagons, for some way towards the centre of each hexagon; and these lines are so gently convergent as to seem nearly parallel. Neither do I remember to have met with such strongly marked central elevations as those represented in the figure cited."

FIG. 6.



POLYGONAL ORNAMENT FROM HEAD-SHIELD OF *Hemicyclaspis Murchisoni* (after Lankester); magnified 7 diameters.

Having carefully examined numerous recent specimens of armour-plated fishes, I was much struck by the foregoing observation of Professor Huxley; as not only applicable to *Cephalaspis*, but to the dermal armour of the entire body of

FIG. 7.

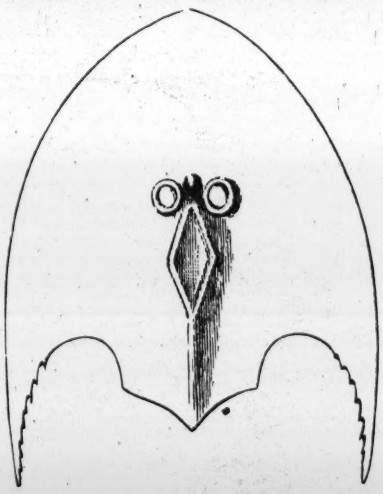


FIG. 7*a*.

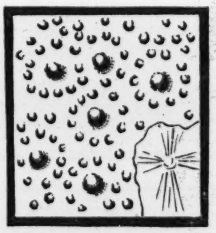
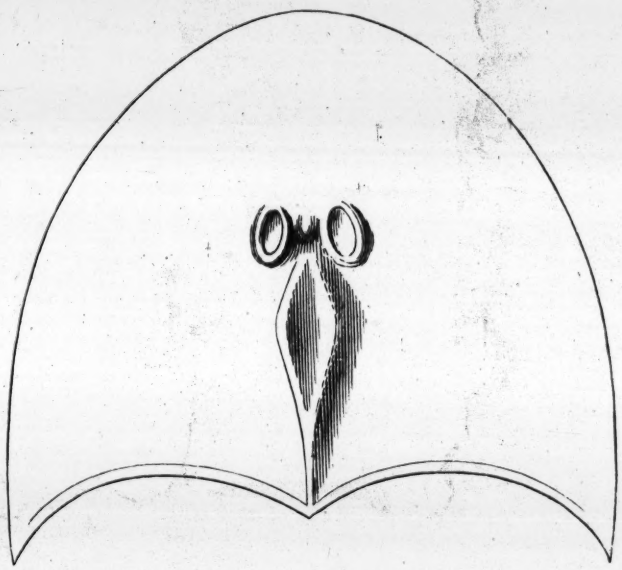


FIG. 7.—OUTLINE OF HEAD SHIELD OF *Eucephalaspis Pagei* (Lankr.).
7*a*.—ORNAMENT OF THE SAME, MAGNIFIED 7 DIAMETERS (after Lankester).

* Op. cit. p. 279.

Ostracion (Pl. II., Fig. 3, *Ostracion bicaudalis*, West Indies), drawn for comparison from a specimen in the British Museum. From the structure and form of these head-shields, and the different position of the eyes in some of them, Professor Lankester has divided the genus *Cephalaspis* into three sub-generic types, namely:—*Eucephalaspis* (Woodcut, Fig. 7), *Hemicyclaspis* (Woodcut, Fig. 8), and *Zenaspis*.

FIG. 8.



OUTLINE OF HEAD SHIELD OF *Hemicyclaspis Murchisoni*, EGERTON (after Lankester).

Eucephalaspis includes the celebrated specimen named by Agassiz after Sir Charles Lyell, in which the form of the body is very well preserved (see restoration, Plate I., Fig. 4).

Other species (*E. Powriei* and *E. Pagei*) have been added by Lankester; also showing the general form of the body, with the pectoral, dorsal and caudal fins; and the *actual* scales, which, in *E. Lyelli*, are not preserved. *Hemicyclaspis Murchisoni* best shows that very peculiar polygonal division of the surface of the carapace (Woodcut, Fig. 6), which Professor Huxley has called attention to (*ante* p. 10). This peculiar ornamentation is *not always* present, other head-shields being ornamented by tubercles of various forms and sizes. (See Woodcuts, Figs. 7*a*, 9, and 10*a*.)

The largest of these buckler-headed fishes belongs to the genus *Zenaspis*, a head-shield having been obtained by Mr. John Edward Lee, F.G.S., from the "Cornstones" (Lower Old Red Sandstone) of Herefordshire, measuring 7 inches by 7 inches.

A characteristic example of *Cephalaspis*, discovered by Principal Dawson, of Montreal, in the Devonian sandstones of Gaspé

Bay, Canada, has been described, and named after its discoverer, by Professor Lankester, in the Geological Magazine for 1870, p. 397, so that this curious genus must now be regarded as common to North America as well as to Britain. (Woodcut, Fig. 9.)

FIG. 9.

1 *Cephalaspis Dawsoni*, LANKESTER (NATURAL SIZE) DEVONIAN, CANADA.
2. PART OF SURFACE OF HEAD-SHIELD OF SAME, MAGNIFIED.

An exceedingly narrow head-shield with enormously developed lateral horns, from the Downton Sandstone (Upper Silurian) Ludlow, is named *Eukeraspis* (Woodcut, Fig. 10). The outer border of the shield in this species is furnished with irregular marginal spines of various length.

Two other British Osteostracous fish-shields have been described. One of these, *Auchenaspis* (Woodcuts, Figs. 11 and 12) is represented by two small shields (named *A. Salteri* and *A. Egertoni*); they are divided transversely into two parts: the anterior semicircular and bearing the eyes, the posterior part oblong and much smaller. The other, named *Didymaspis*, represented by a single specimen (*D. Grindrodi*) is divided like the preceding, but the anterior part is without prominent cornua (Woodcut, Fig. 13), and nearly oval in outline. The former (*Auchenaspis*) occurs in the "Tilestones" and Passage-beds at Ledbury and Ludlow; the second (*Didymaspis*) is found in the Old Red Sandstone of Ledbury.

Since the researches into the Fossils of the Old Red Sandstone first began in this country, probably no name has become more familiar to geologists and general readers than that of Hugh

FIG. 10.

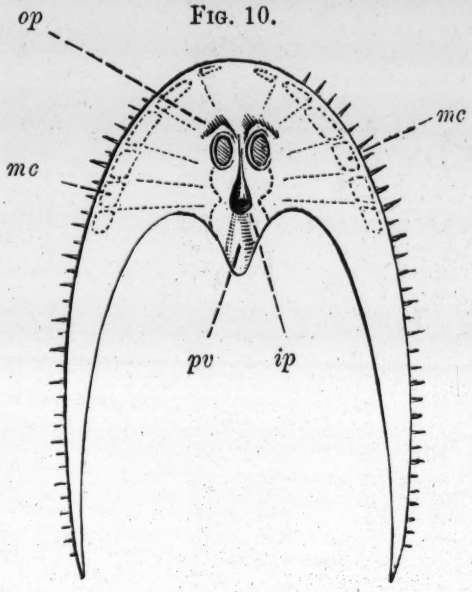


FIG. 10*a*.

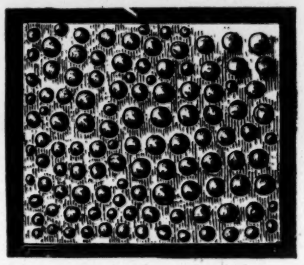


FIG. 10. OUTLINE OF HEAD-SHIELD OF *Eukeraspis pustuliferus*, AGASSIZ.
op. orbital prominences; *mc.* marginal cavities; *pv.* post orbital valley; *ip.* interorbital prominence.
FIG. 10*a*. ORNAMENT OF SAME, MAGNIFIED 7 DIAMETERS (after Lankester).

Miller,* the self-taught naturalist, author, and stone-mason of Cromarty, whose whole career is replete with life-studies illustrative of that patient indomitable courage, which never looks

FIG. 12.

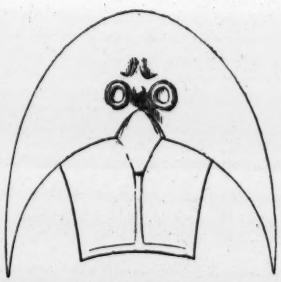


FIG. 13.

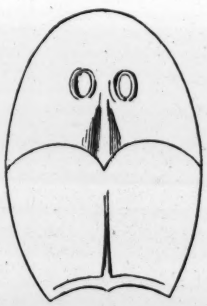


FIG. 11.

FIG. 11. *Auchenaspis Salteri* (Egerton).
„ 12. *A. Egertoni* (Lankr).
„ 13. *Didymaspis Grindrodi*, Lankr. (after Lankester).

* *See* "The Old Red Sandstone, or New Walks in an Old Field," 3rd edit. 1847. "Footprints of the Creator, or the *Asterolepis* of Stromness," 1st edit. 1849. "The Cruise of the Betsey, or a Summer Ramble among the Fossiliferous Deposits of the Hebrides."

upon any aim as unattainable that may be won by steady honest perseverance. It is especially with reference to his discoveries of those strange armour-plated fishes in these Scottish deposits that his name deserves to occupy a prominent place in the present article.

One of the most remarkable of Hugh Miller's discoveries was that of the *Pterichthys*, obtained in 1831, but only made known in 1838, and named by Agassiz, at the Glasgow Meeting of the British Association in 1840, *Pterichthys Milleri*. (Pl. I., Fig. 5.)

"When first brought to light by the single blow of a hammer, there appeared on a ground of light-coloured limestone the effigy of a creature, fashioned apparently out of jet, with a body covered with plates, two powerful-looking arms, articulated at the shoulders, a head as entirely lost in the trunk as that of the ray (or skate), and a long angular tail, equal in length to a third of the entire figure."*

A glance at our illustration forcibly reminds one of a man in a diver's dress with its windowed helmet, or of that quaint costume of *papier-maché* and metal-work, regularly worn by the Japanese night-watch only fifteen years ago!†

The head and the fore part of the body are defended by plates of hard bone, coated with enamel (thence called "ganoid plates"); those of the trunk forming a buckler, composed of a back-plate and breast-plate, articulated together at the sides. The rest of the body was defended by small enamelled bony scales, thus giving it, like the old scale-armour, at once strength and flexibility. The fish had a small back fin, and a terminal heterocercal tail-fin; but these are very rarely displayed in fossil specimens. The pectoral spines, *c*, *c*, are also formed of the same ganoid material, like the buckler. The armour of the head, or helmet, appears to have been articulated by a movable joint to the trunk-buckler.

The pectoral spines consist of two principal joints or segments, both defended by finely tuberculated ganoid plates, like those of the head and trunk. From their form they would seem to have served to aid the fish in shuffling along over the sandy bottom or bed of an estuary if left dry at low water. The fins attached to the flexible part of the body indicate a certain power of swimming, though not with any great rapidity; they include a small dorsal and a pair of ventrals; these latter were first observed by Sir Philip Grey-Egerton. The jaws are small, and are armed with confluent denticles. (Owen.)

* *See* "Life of Hugh Miller." By Sir David Brewster.

† Now only to be seen in Museums or in private collections of arms and armour. One is just now for sale, at Wright's, 90 Great Russell Street, being part of the Whitworth collection of armour.

We come next to the genus *Coccosteus** of Agassiz, in which, as in *Pterichthys*, already noticed, the dermal armature was composed of numerous plates, soldered together at their sutures, like "trusty knight in armour dight"—furnished with both back and breast-plate well rivetted together.

The external surface of these bony buckler plates in *Coccosteus* is ornamented with small hemispherical tubercles; from this fact the generic name, signifying "berry-bone," is derived. The similarity of this ornamentation to that of the plates of the buckler in some tortoises led to the belief, when these coccosteal plates were first discovered, that they were evidence of the presence of Chelonians in the Devonian beds. They have even been regarded at one time as parts of some crustacean carapace.

Alluding to Pander's restoration (Pl. II., Fig. 1), Professor Owen remarks :† "If a heterocercal fin were added to the restoration, a correct idea would be given of the Old Red fossil, which, in the progress of its construction, has suggested such diverse notions of its nature and affinities.

"The helmet and cuirass are firmly united, and there is no trace of the jointed appendages, like pectoral fins, which characterize *Pterichthys* (Pl. I., Fig. 5, *c*, *c*). The unprotected part of the trunk shows an ossification of the neural and hæmal spines (*n* and *h*), and of their appendages, the rays of the 'dorsal' and 'anal' fin (*d* and *a*); and by the analogy of *Cephalaspis* (Pl. I., Fig. 4), the tail was most probably terminated by an unequal-lobed fin (*c*). The lower jaw is composed of two rami, loosely connected at the symphysis; so that being displaced and crushed in fossil specimens, they gave rise to the notion of the fish being provided with laterally-moving jaws, like those of the lobster. But the lower jaw worked vertically upon a fixed upper one; both jaws being provided with from ten to twelve teeth on each side, anchylosed to the bone."

The blank space (*ch*) seen in fossil specimens, between the neural (*n*) and hæmal (*h*) spines, indicates the position of the soft "notochord" which has been dissolved away. The cylindrical gelatinous body, so-called (in Latin *chorda dorsalis*), exists before the formation of the bony bodies, or *centra*, of the vertebræ in all vertebrate animals: and the development of those bodies seems never to have gone beyond this embryonal phase in any palæozoic fish. Hence they have been called "notochordal" fish, on account of their retaining the notochord. (Owen.)

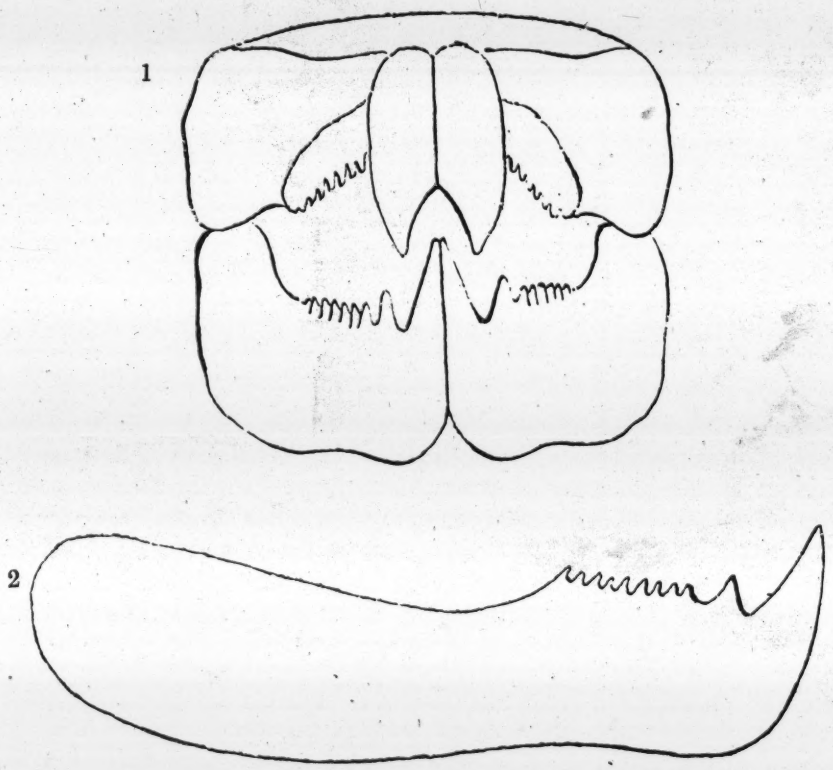
* So called from κόκκος a berry, and ὀστεόν bone, in allusion to the surface of the plates being everywhere covered with small berry-like tubercles. (*See* Woodcut, Fig. 10*a*, *Eukeraspis*, but which conveys a good idea of the surface ornamentation of *Coccosteus*.)

† "Palæontology," p. 145.

Closely allied to Agassiz's genus *Coccosteus*—if not probably identical with the great Cromarty fish discovered by Hugh Miller, but of far more gigantic proportions—is the great Placoderm described by Professor Newberry* from the Upper Devonian Black Shales of Delaware, Ohio.

This enormous armour-plated fish, for which the name *Dinichthys* has been proposed, deserves the same distinction among fishes as the Dinosaurians among Reptiles, and the *Dinornis* among birds.

FIG. 14.



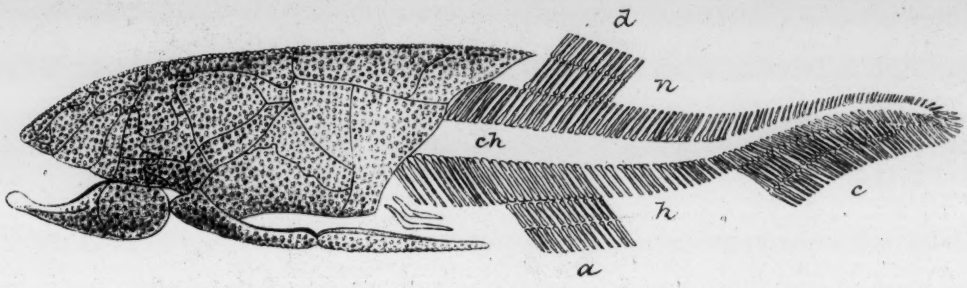
1. ANTERIOR ASPECT OF HEAD OF *Dinichthys Herzeri* ($\frac{1}{8}$th natural size).
2. MANDIBLE OF SAME ($\frac{1}{8}$th natural size).

Most of the bones obtained belonged to the head, which was about three feet in breadth and nearly three inches in thickness, being strengthened at the occiput with internal ridges. The jaws were each two feet in length. The external surface of the bony plates is ornamented with very fine vermicular markings. The body is estimated to have been about 15 feet in length.

The anterior part was protected, as in *Coccosteus*, by huge dorsal and ventral shields; and from the absence of scales, it

* State Reports, "Palæontology of Ohio," Vol. ii. "Geol. Mag." 1868, Vol. v. p. 184, and 1877, Decade ii. Vol. iv. p. 213.

1



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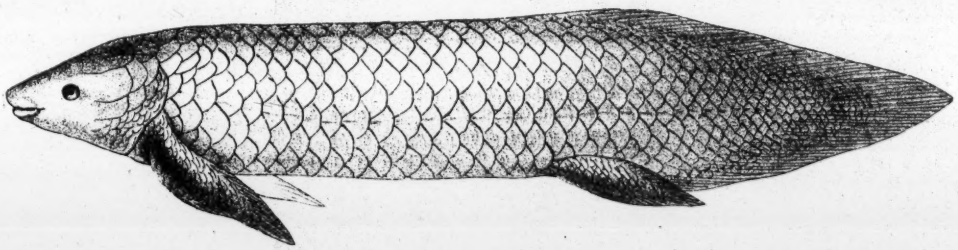

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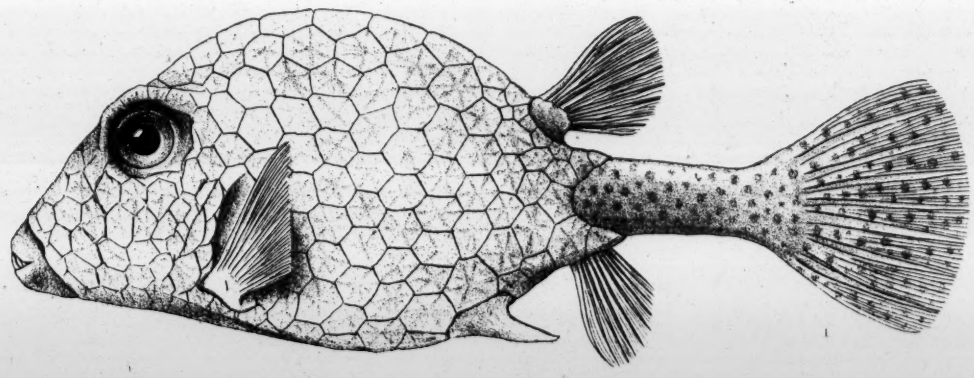


W. West & Co. imp.

Coccosteus. 2. Ceratodus. 3. Ostracion.

seems probable that the rest of the body was only covered with a tough skin. Like the modern sheat-fish of the Ganges, it may have protected itself by burrowing in the mud and watching for its prey, with only its mail-clad parts exposed.

The powerful dentition of *Dinichthys* is suggestive of its carnivorous habits; and being so heavily weighted by the thick shields encasing its vital organs, it would be compelled to obtain food rather by cunning than by swift pursuit. These heavily armed Placoderms had only a comparatively short range in time, remains of the group being found only in the Upper Silurian and Devonian rocks. Thus it seems, as though unable to cope in the struggle for existence with the lighter armed and more active race of ganoids which predominated in the Devonian waters, they died out, leaving no immediate descendants.*

Dinichthys, like *Coccosteus*, appears to have had an unossified notochord.

But besides the "Lancelet" (*Amphioxus*)—the most lowly organized of existing vertebrates—three genera, belonging to the highest order of fishes—the Dipnoi (or double-breathers)—living at the present day, all exhibit the same embryonal structure in the adult state, namely, the *Lepidosiren* found in the Amazons, South America, the *Protopterus* of the African rivers, and the *Ceratodus* (Plate II., Fig. 2) of the Australian rivers.

These remarkable fishes have the swim-bladder modified into true internal lungs, whilst they retain internal branchiæ, so that they are capable of existing either in the water or on land. During the rainy season, large rivers like the Amazons and the Gambia are subject to overflow, whilst those of the Australian continent are not only liable to overflow, but are subject to long continued periods of drought, during which the waters sink so low that the beds of the rivers are frequently dry, and water is only found in deep hollows ('waterholes') or in muddy pools. The *Protopterus* and *Lepidosiren* bury themselves in the mud, and breathe by means of their lungs until the return of the rainy season sets them free once more to pursue an aquatic existence. The *Ceratodus*, if unable entirely to subsist without water, can nevertheless live in water so muddy as to be unfit for branchial respiration, and to come to the surface and breathe air direct by means of its modified swim-bladder. But Dr. Günther†

* A. Crane, "Geol. Mag." 1877, Vol. iv. p. 214.

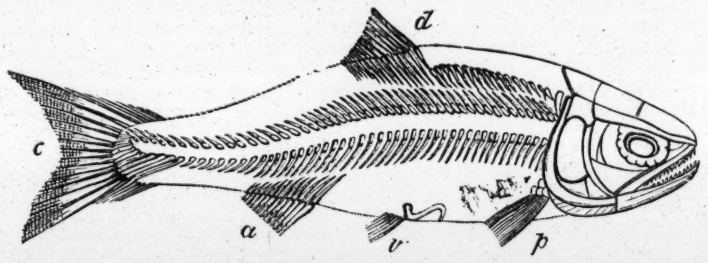
† "Description of *Ceratodus*, a Genus of Ganoid Fishes, recently discovered in the Rivers of Queensland, Australia." By Dr. A. Günther F.R.S. "Phil. Trans." 1871. Part II. p. 511.

is of opinion that *Ceratodus* is not adapted to quit the water entirely, the limbs being much too flexible to support so heavy and unwieldy a body, and too feeble to be of much use in locomotion on land.

Ceratodus belongs to a most ancient order of fishes, and is represented in the Oolitic and Rhætic beds, and in the Trias and Coal-measures, by fossil teeth almost identical with those of the living Australian lump-fish.

Whilst dwelling on the persistence of embryonic characters in the adult, it is interesting to observe that in an extinct group of homocercal fish of the family Caturidæ, (Woodcut, Fig. 15) characteristic of the Oolitic and Liassic periods,* all the species are homocercal and *notochordal.*

FIG. 15.†



Caturus furcatus, OOLITE, SOLENHOFEN (after Owen).
p. pectoral; *v.* ventral; *a.* anal; *d.* dorsal; *c.* caudal fin.

We have already pointed out that in the earliest shield-bearing fossil fishes of the Upper Silurian epoch, the Cephalaspidæ (Placo-Ganoidei), there is no evidence whatever to show that they possessed any internal skeleton. They probably represented a group of fishes in which not only was the notochord persistent, but the neural and hæmal processes were alike wanting, as in *Amphioxus.*‡

In the Chondrostei, represented at the present day by the Sturgeon (*Acipenser*), the notochord is persistent, whilst the formation of the arches and their appendages does not pass beyond the cartilaginous stage. The head is covered by "ganoid" plates, joined by sutures, whilst detached bony plates occur in rows along the body. (See Plate I., Fig. 6.)

* *Caturus similis*, Agassiz, from the Chalk of Lewes, is a mere fragment of a jaw, to the determination of which no importance need be attached.

† For permission to use this figure (reproduced from Prof. Owen's 'Palæontology,' p. 163), we are indebted to the kindness of Messrs. A. & C. Black, Edinburgh.

‡ Or the neural processes may have had a rudimentary development, as in the Lamprey (*Petromyzon*); Marsipobranchii.

The genus *Chondrosteus* carries this type back as far as the Lias period.

In the Placodermi, represented by *Dinichthys*, *Coccosteus*, and *Pterichthys*, we have a somewhat further advance in the ossification of the neural and hæmal spines and of the appendages of the rays of a "dorsal," "anal," and caudal fin, the head and anterior portion of the trunk being, at the same time, encased in dermal bony plates.

The cartilaginous heterocercal-tailed sharks,* with partially ossified endoskeleton, and a covering of skin, toughened with shagreen, tubercles, and spines, belong to an ancient tribe of fishes whose progenitors probably date back to Upper Silurian times.

The bony pike† (*Lepidosteus*) of the American rivers, and the *Polypterus*‡ of the Nile and Senegal, are the best living exemplifications of the old bony-scaled ganoids—fishes clad in a complete suit of enamelled armour, which, beginning with *Osteolepis* in the Devonian, attained their maximum development in Mesozoic times. The vertebral column in *Lepidosteus* is more perfectly ossified than in any other fish, the vertebræ are remarkable as being opisthocœlian in type (hollow behind, convex in front).

The *thin-scaled* homocercal Caturidæ (see woodcut, Fig. 15), with well ossified head-plates, neural and hæmal appendages, and fin-rays, but with persistent notochord, seem to mark the incoming of our modern form of fishes.§

In the Cretaceous formation the Teleostian, or well ossified bony fishes, are numerous, and also fishes with flexible "cycloid" and "ctenoid" scales. The order Teleostei includes the majority of existing fishes, as well as those which made their appearance in Tertiary times.

Concerning the last and highest group of which we have spoken—the Protopteri of Owen, or Dipnoi of Müller—we venture to think a strong case might be established for removing these anomalous forms across the border-line of the class Fishes, and placing them with the Amphibia.

There is no tendency, either in *Lepidosiren*, or in *Ceratodus*, to produce those unpaired fins ("dorsal" and "anal"), or the

* *Plagiostomi* (Müller) = *Elasmobranchii* (Bonaparte).

† *Lepidoganoidei*, sub-ord. *Lepidosteidæ* (bony-scaled).

‡ *Lepidoganoidei*, sub-ord. *Crossopterygidæ* (fringe-finned).

§ "Cycloid" fish scales were noticed by Mr. C. B. Rose, F.G.S., in the Kimmeridge clay, Ely, and in Norfolk; others have been noticed by Mr. W. Davies, F.G.S., in the British Museum, from the same locality. *See* "Geol. Mag. 1864, Vol. i. pp. 92–94.

paired "branchial" fins, so characteristic of true fishes, but only those pairs of locomotory organs which are homologous with the limbs of higher vertebrate animals, namely, the "pectoral" and "ventral" fins.

Even in the Crossopterygidæ (*Osteolepis*, &c., and *Polypterus*), which present some affinities with *Ceratodus*, dorsal and anal fins are present. The double air-bladder of *Polypterus* only approximates to the reptilian-like lungs of *Ceratodus* and *Lepidosiren*. It is worthy of remark that Professor Owen, whilst retaining the Protopteri with the Fishes, prints against the order the significant word "(*Transitional*")."*

Dr. Melville, who devoted careful attention to *Lepidosiren annectens*, in 1847,† regarded it as a *true Amphibian*. For this conclusion he relied on the absence of the supra-occipital bone, the presence of the large epi- and basi-cranial bones, the non-development of the maxillary and inter-maxillary bones, and especially the enormous development of the Wernerian bones, which become subservient to mastication and are anchylosed to the expanded pterygoids; on the nostrils being double; on the existence during the adult condition of external cutaneous gills which do not occur in any fish; and on the coexistence of external and internal gills, with lungs: in other words, on its exhibiting the different modes of circulation, respiration, &c., observable in the second stage of the larva of the frog, and in *Amphiuma* or *Menopoma*, &c.

In the Amphibia of the order Labyrinthodontia, of the Upper Coal period, one genus at least, *Archegosaurus* (though probably there are others besides), has the notochord persistent, the vertebral arches and peripheral elements only being ossified: it is covered with small narrow sub-ganoid scales, and there are traces of branchial arches. The skull in its combined dermo-neural ossification resembles that of the Sturgeon and of *Polypterus*, &c. (Owen.)

In the Amphibia of the order Ophiomorpha, branchial clefts and rudimentary branchial filaments have been observed. These strange snake-like amphibians have transverse rows of "cycloid" scales imbedded in their integument. When adult respiration is carried on by lungs; the vertebræ are *amphicœlian*,‡ a character common to most fishes and to some reptiles.

Referring to the Amphibia, Professor Huxley observes, they "are distinguished from the *Sauropsida* and *Mammalia* by very

* Owen, "Comp. Anat. Verteb." 1866, Vol. i. p. 14.

† A. G. Melville, on the Lepidosiren, in Report of Brit. Assoc. Adv. Sc. 17th Meeting, 1847, Transact. Sect. p. 78.

‡ Hollow at both ends.

important and sharply defined characters. . . . From *Pisces*, on the other hand, they are distinguishable only by the characters of their locomotive apparatus. When they possess median fins and limbs, these never present fin-rays, and the limbs exhibit, *in full development*, the type of structure which obtains among the *Sauropsida* and *Mammalia*, and differ very widely from the fins of any fish at present known."*

He adds:† "With respect to the origin of the Amphibian stock itself, the following considerations appear to be of fundamental importance:—The early stages of development of the *Amphibia* do not resemble those of any known ganoid, teleostean, or elasmobranch fish, and are similar to the corresponding stages of the *Marsipobranchii*, *Myxine*, *Petromyzon*." "The skull of the tadpole has much in common with that of *Chimæra* and with that of the *Dipnoi*, *Ceratodus*, *Lepidosiren*." "The only *Vertebrata*, besides *Amphibia*, which have transitory external gills, are the *Elasmobranchii* (*Squalidæ*, *Raiidæ*, *Chimæridæ*), the *Dipnoi*, and perhaps some ganoids." "The only fishes which possess morphological (*Polypterus*) or functional (*Dipnoi*) lungs are the ganoids and *Dipnoi*." "The conclusions suggested by these facts appear to be that the *Amphibia* took their origin from some primordial form common to them, the *Elasmobranchii*, the *Ganoidei*, and the *Dipnoi*, and that the main distinction by which their earliest forms were marked off from those of the other groups was the development of that pentadactyle type of limb which is common to all the higher *Vertebrata*." "And seeing that the elasmobranch, ganoid, and dipnoous types were fully differentiated from one another in the Devonian epoch, it is reasonable to believe that the existence of the *Amphibia* as a group dates back at least as far as that remote period of the earth's history."

As bearing upon this subject it is interesting to notice that among the remarkable assemblage of Reptilia from South Africa, lately described by Professor Owen, is a Dinosaurian Reptile (*Tapinocephalus Atherstoni*) in which my colleague Mr. Davies detected the curious fact that the vertebræ, like some fishes, have an *amphicœlous* form, being almost notochordal within, owing to the imperfect ossification of their centra.

If the suggestions contained in the foregoing pages, as to the persistent notochord in early vertebrates, be of any genealogical or morphological value, then it may serve to indicate the earliest forms in each group, and even their relative development.

* "Encyclopædia Britannica," article *Amphibia*, Vol. i. 1875, p. 750.

† Op. cit. p. 770.

Thus we should have the following modifications in PISCES*:—

? Proto-amphioxus.	*Notochordal*—destitute of endo- or exoskeleton; respiratory and alimentary system rudimentary—resembling the *Tunicata*. No fossil type known.

(*First fishes actually known*).

Cephalaspidæ.	*Notochordal*—endoskeleton absent (or rudimentary ?); exoskeleton in the form of bony head-shield and, in some, dermal scutes.
Placodermi.	*Notochordal*—peripheral processes of endoskeleton (and fin-rays) ossified; exoskeleton well developed anteriorly, both on dorsal and ventral surface.
Chondrostei.	*Notochordal*—peripheral endoskeleton cartilaginous, rudimentary; head covered by dermal plates—scutes in rows on body.
Crossopterygidæ.	*Notochordal*—peripheral endoskeleton partly ossified; dermo-cranial bones, coated with enamel; scales rhomboidal or cycloidal; fins lobate, paired, central axis of fin covered with scales; air-bladder double-celled, in some the walls are ossified.
Lepidosteidæ.	Vertebral skeleton, *perfectly ossified*; exoskeleton a complete suit of enamelled bony plates and scales.
Plagiostomi or *Elasmobranchii.*	*Vertebræ*—partly ossified, partly cartilaginous; endoskeleton chiefly cartilaginous; skin roughened with shagreen, tubercles, and spines.

(*Incoming of thin-scaled fishes*).

Caturidæ.	*Notochordal*—neural and hæmal processes well developed; head with ganoid covering; body covered with *thin* scales.

(*Modern fishes*).

Teleostei.	Endoskeleton well ossified; dermal covering consisting of thin "cycloid," or "ctenoid," scales.

(*Transitional forms*, or possibly *Amphibia?*)

Protopteri or *Dipnoi.*	*Notochordal*—neural and hæmal processes ossified; only two pectoral and two ventral fins; dermal covering of cycloidal scales; functional internal branchiæ and well developed internal lungs.

EXPLANATION OF PLATE I.

FIG. 1. A portion of the test of *Scaphaspis Lloydii*; considerably enlarged, to show the form of the surface-ridges and the coarser structure of the lower layers of the shield. The piece is from near the centre of the shield. Observe the flatness of the ridges *a* = the outer, or 'striated' layer; *b* = the middle, or 'cancellated' layer; *c* = the inner, or 'nacreous' layer (after Lankester).

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* These cannot be deemed to be placed in their proper classificatory order, but only to show the gradations of skeletal development.

FIG. 2. A fragment of *Pteraspis rostratus* showing well the 'cancellated layer' (*b*) with its polygonal cavities, the letters correspond with those of Fig. 1.

FIG. 3. Microscopic structure of shield of *Pteraspis rostratus*—a section cut parallel to the ridges. The vascular tufts and their connection with the polygonal cavities (*b*) are well seen (Lankester).

FIG. 4. Restoration of *Eucephalaspis Lyelli* (after Lankester). *p* = pectoral; *d* = dorsal; *c* = caudal fins.

FIG. 5. Restoration of *Pterichthys Milleri*, Ag. Old Red Sandstone, Cromarty (after Pander); *c, c*, the pectoral fins.

FIG. 6. Diagram figure of the Dermo-skeleton of the Sturgeon's head (*Acipenser sturio*), after Owen; *ch* = the persistent notochord.

EXPLANATION OF PLATE II.

FIG. 1. Restoration of *Coccosteus decipiens*, Old Red Sandstone, Russia (after Pander); *ch* the undivided notochord; *n* = neural spines; *h* = hæmal spines; *d* = dorsal; *a* = anal fin-rays; *c* = the caudal fin.

FIG. 2. *Ceratodus Forsteri*, a living Dipnoid fish found in the rivers of Queensland, Australia (after Günther).

FIG. 3. *Ostracion bicaudalis* (the Trunk-fish), West Indies. Drawn from a specimen in the Zoological Gallery, British Museum.

THE OLD AND THE NEW CHEMISTRY.

By M. M. PATTISON MUIR, F.R.S.E.

THERE have recently appeared in the *Comptes Rendus*, and in the *Archives des Sciences physiques et naturelles*, a series of communications by Wurtz, Berthelot, and Marignac upon the merits of the two systems of chemical notation based respectively upon the use of equivalents, and upon that of atomic weights.

The echoes of the old strife, once so fiercely waged by the opposing schools, have almost died away in this country; is it not possible that the lessons which the history of the warfare is fitted to teach are also beginning to be forgotten by the chemists of to-day?

Let us briefly glance backward at the page of chemical history which tells of the conflict of the atomists and the upholders of an equivalent notation.

Until the time of Black, Cavendish, Priestley, Lavoisier and his associates, chemistry can scarcely be called an exact science. Many experiments had been performed by the older chemists, and many facts had been amassed; but their experiments were for the most part vague, and their facts inexact.

The rise of quantitative chemistry necessitated the adoption of a quantitative notation.

In 1777 Wenzel determined, with very considerable accuracy, the amounts of potash and of lime which were required to neutralize given quantities of sulphuric and of nitric acid. He found that 123 parts of lime and 222 parts of potash severally neutralized 240 parts of nitric acid and 181·5 parts of sulphuric acid. Hence arose the idea of equivalency. So far as their power of neutralizing sulphuric or nitric acid was concerned, 123 parts of lime were equivalent to 222 parts of potash.

Passing over a period of about fifty years—a period fraught with all-important issues in chemical science—we find the idea of equivalency coming into general favour among chemists. The researches of Lavoisier, of Cavendish, of Berzelius, and of others had introduced an accuracy into chemical experiment

which had been unknown in the time of Wenzel. The fact of constant composition of compounds had been firmly established: careful analyses of series of compounds of the same element had shown that a number may be attached to each element expressing the relative amount of that element which combines with other elements to form compounds. This number was called the equivalent of the element.

Hydrogen and oxygen combined in the proportion of 1 to 8; hydrogen and sulphur in the proportion of 1 to 16; hydrogen and nitrogen in the proportion of 1 to 4·66. Hence 8 parts by weight of oxygen were equivalent, so far as the power of combining with hydrogen was concerned, to 16 parts of sulphur, and to 4·66 parts of nitrogen.

Hence in the equivalent notation the compounds of hydrogen and oxygen, of hydrogen and sulphur, and of hydrogen and nitrogen would be represented by the formulæ HO, HS, and HN, respectively; and the equivalents of oxygen, sulphur, and nitrogen would be 8, 16, and 4·66 respectively.

But oxygen and nitrogen form a series of well-marked compounds; the proportion of oxygen to nitrogen in the compounds was found to be (1) 8 : 14, (2) 16 : 14, (3) 24 : 14, (4) 32 : 14, (5) 40 : 14. In no member of the series were there less than 14 parts of nitrogen, the amount of oxygen being taken as 8.

But the study of the three compounds HO, HS, and HN showed that 8 parts of oxygen were equivalent to 4·66 parts of nitrogen: hence it appeared that in the lowest member of the nitrogen and oxygen compounds there were 3 equivalents of nitrogen; the formulæ of the series would then be ON_3, O_2N_3, O_3N_3, O_4N_3, and O_5N_3.

But these formulæ were not adopted. It was assumed that the true equivalent of nitrogen was 14, and that the formula of the compound of this element with hydrogen was H_3N: hence the formulæ of the compounds with oxygen became ON, O_2N, O_3N, O_4N, and O_5N, respectively.

From certain data the formula of phosphoric acid was deduced as PO_5, that of sulphuric acid as SO_3; but the amount of the former acid, expressed by the formula PO_5 was capable of neutralizing three times as much soda, or oxide of silver, as the amount of the latter acid expressed by the formula SO_3: hence the true equivalent formula of phosphoric acid should have been written $\frac{1}{3}$ PO_5.

The study of reactions frequently led to the adoption of several equivalents for one and the same element: to carbon, for instance, the equivalents 3, 4, 6, 8, and 12 were given according to the compound or compounds from the composition of which the number was deduced.

These and similar facts were felt to militate against the universal adoption of a notation based upon equivalents.

In the year 1808, Gay Lussac announced the fact that there exists a simple relation between the volumes in which elementary gases combine, and also between these volumes and the volume of the product, provided that product be gaseous.

Hydrogen and oxygen combine—Gay Lussac showed—in the proportion of two volumes to one volume; the product is two volumes of aqueous vapour. Hydrogen and nitrogen combine in the proportion of three volumes to one volume; the product is two volumes of ammonia gas. Nitrogen and oxygen combine in the proportion of two volumes to one volume; the product is two volumes of nitrous oxide gas. Extended experiments have shown that, as a very general rule, two volumes of any compound gas contain 1, 2, 3, &c. volumes of the elementary gases composing the compound body; or, in other words, if we adopt two volumes of a compound as the standard, we can express the volumes of the constituent elements in whole numbers. Further, experience has shown that the number representing the smallest (relative) amount of an element in two volumes of any of its gaseous compounds, also represents the proportion, *by weight*, in which that element combines with other elements: we may call this number the *combining number* of the element. Thus, the smallest amount of oxygen in two volumes of any gaseous compound of this element—hydrogen being the unit of the scale—is 16. All known gaseous compounds of oxygen may be represented as containing 16, or a multiple of 16, parts by weight of that element. The smallest amount of nitrogen in two volumes of a gaseous compound of nitrogen is 14. All gaseous nitrogen-compounds may be represented as containing 14, or a multiple of 14, parts by weight of that element.

Hence, if we adopt two-volume formulæ, we are enabled to attach to each element a number expressing the proportion by weight in which that element combines with other elements to form compounds.

Now, in the equivalent system of notation, as strictly carried out, no such generalization was possible. The equivalents 3, 4, 6, &c. might be assigned to carbon. In marsh gas 3 parts by weight of carbon are combined with 1 part by weight of hydrogen; in ethane 4 parts of carbon are combined with 1 of hydrogen; in ethene 6 parts of carbon are combined with 1 of hydrogen. Are we to represent carbon compounds as containing multiples of 3, multiples of 4, or multiples of 6 parts by weight of carbon? We are perfectly entitled, on the system of notation by equivalents, to adopt the formula CH as expressing the composition of each of the gases already mentioned, giving to C a different value in each formula. Or, if we adopt—as was actually done—6 as the equivalent of carbon,

then we may write the formulæ of these three bodies as C_3H, C_3H, and CH, or, to avoid fractional numbers, as CH_2, C_2H_3, and CH respectively. But these formulæ represent different volumes of the compounds. Let us take CH as the standard; let the amount of this gas represented by this formula occupy 1 volume, then the amount of the gas CH_2 represented by that formula occupies 2 volumes, the amount represented by C_2H_3 also occupies 2 volumes.

Further, these equivalent formulæ altogether fail to generalize the reactions of the compounds which they represent.

The old notation is said to be founded on facts and on facts alone. Numbers are attached to the elements representing the equivalents of these elements: the elements combine in the proportions expressed by these numbers, or by simple multiples of these numbers. But we have seen that to many elements 1, 2, 3, 4 or more equivalents may be assigned; which is the true equivalent? Further, we have seen that the old notation sometimes assigned an equivalent to an element which is really not the equivalent, not even *an* equivalent, of that element. The equivalent of nitrogen was said to be 14; but, as a matter of fact, 14 parts by weight of nitrogen are always found united with 3, not with 1 part by weight of hydrogen. The old notation made but little use of Gay Lussac's great generalization concerning combination by volume.

Lastly, the old notation very frequently failed, if rigidly carried out, to generalize the properties of the bodies to which it assigned formulæ.

I have shown that by adopting formulæ representing the weights of two volumes of compounds, and by carefully analysing series of compounds, we arrive at certain numbers which express the least (relative) amounts of the elements in the two volumes, and also the amounts of those elements which combine to form other compounds.

So far we have made no use of the idea of equivalency. But when we come to compare together the amounts of the different elements represented by their combining numbers, as deduced by the process just mentioned, we find that, judged by a certain standard, these amounts sometimes are, and sometimes are not, equivalent to each other. Thus, the combining number of carbon is 12, of oxygen 16, and of nitrogen 14. But 12 parts by weight of carbon combine with 4 parts of hydrogen to form 2 volumes of a gaseous compound; 16 parts of oxygen combine with 2 parts of hydrogen to form 2 volumes of a gaseous compound; and 14 parts of nitrogen combine with 3 parts of hydrogen to form 2 volumes of a gaseous compound. Further, $2 \times 16 = 32$ parts of oxygen are capable of replacing the hydrogen in 2 volumes of the gaseous compound of carbon

and hydrogen referred to in the preceding sentence, the resultant gas occupying 2 volumes. Hence we conclude that, so far as the power of combining with or of replacing hydrogen is concerned, the amount of carbon expressed by the combining weight is equivalent to twice the amount of oxygen expressed by the combining weight of that element, or to $1\frac{1}{3}$ time the amount of nitrogen expressed by the combining weight of that element. Or, if the letters C, O, and N represent 12, 16, and 14 parts of the elements carbon, oxygen, and nitrogen respectively, then, so far as the power of combining with or of replacing hydrogen is concerned,

$$C = 2O$$
$$3C = 4N;$$

or to put the same statement in another form:

$$C = 4H$$
$$O = 2H$$
$$N = 3H.$$

In such form as this have the long known facts concerning equivalency found a place in modern chemistry. We compare the amounts of the elements expressed by their combining weights (deduced from the two-volume formulæ of compounds) with reference to their power of replacing or of combining with hydrogen, and we arrive at certain wide and well-marked generalizations.

The new chemistry finds a place for the idea of equivalency.

If the combining number of each element be divided by the equivalent of that element, a number is obtained expressing the *valency* of the element. But we have found that an element may have more than one equivalent; the valency of an element may therefore vary. Each element has, however, a maximum valency.*

The combining numbers of the elements are deduced, it has been said, from analyses of two volumes of their gaseous compounds. But we are acquainted with very few gaseous compounds of a large number of the elements; nevertheless a number is assigned to every element purporting to be the combining number of that element. How are these numbers obtained?

In the year 1819 Dulong and Petit announced, as the result of experiment, that the specific heats of a number of elementary bodies are in an inverse ratio to the combining numbers of these bodies.

The combining numbers of mercury, sulphur, phosphorus, bismuth, &c., as deduced from analyses of gaseous compounds,

* I cannot here discuss the opposing theories of varying and unvarying valency.

when multiplied into the specific heats of these elements, yielded an approximately constant number. Specific heat × combining number = constant = 6·4. This statement was shown by Dulong and Petit to hold good for 13 solid elements. Since the time of its announcement the truth of the statement has been proved in the case of a considerable number of other elements. Chemists are now, for the most part, convinced that a safe generalization may be made to the effect that combining number × specific heat = constant = approximately, 6·4.

If this statement be accepted, it follows that

$$\frac{6{\cdot}4}{\text{Spec. heat}} = \text{approximately, combining number.}$$

If, therefore, we are unable to find a series of gaseous compounds of an element whose combining number we are desirous of determining, it is sufficient that we determine the specific heat of that element, and divide the number so obtained into 6·4: the result will approximately represent the combining number required. By careful analysis of one or more compounds of the element in question we shall then be able to determine with very considerable accuracy the true combining number. The specific heat of silver was determined by Regnault to be $0{\cdot}057 : \frac{6{\cdot}4}{{\cdot}057} = 112{\cdot}28$: the combining number of silver is therefore about 112. But careful analysis of silver chloride shows that this substance contains silver and chlorine in the proportion of 107·66 parts of the former to 35·46 parts of the latter. From analyses of gaseous compounds of chlorine, the combining number of this element has been determined to be 35·46: hence we conclude that the combining number of silver is 107·66. Had the specific heat determination yielded a number half of that actually obtained, we should have adopted $107{\cdot}66 \times 2 = 215{\cdot}32$ as the combining number of silver.

On the old equivalent system of notation, numbers were given to the elements, the products of which into specific heat were sometimes equal, approximately, to 3, sometimes to 6, and in a few cases to 2. No far-reaching generalization could be made expressing the relation between specific heat and equivalent number.

In the year 1820 Mitscherlich announced, as the result of careful study, that there exists a close relationship between the crystalline form and the chemical composition of compound bodies. If two compounds have a similar crystalline form they have also a similar chemical composition. This fact was applied in the determination of the combining numbers of many elements. The combining numbers of the elements in a compound being

known, and the crystalline form of that compound having been determined, it was only necessary to determine the quantity of the element whose combining number was desired, which was capable of replacing an amount of one of the elements in the compound represented by the combining number of that element, without altering the crystalline form of the compound, in order to fix the required number. Thus, the crystalline forms of copper sulphate and iron sulphate are similar: the combining number of copper is 63·2; but the amount of iron which replaces this amount of copper without altering crystalline form is represented by the number 56. Hence 56 is the combining number of iron.

If the equivalent system of notation were rigidly carried out Mitscherlich's law of isomorphism, as it is termed, remained unexplained—a fact by itself without a place in the general theory of chemistry.

The combining numbers obtained from a study of the crystalline forms of compounds are generally the same as those obtained from analyses of gaseous compounds, and from specific heat determinations. There are, however, many precautions to be taken in the practical application of Mitscherlich's generalization.

If the elements be arranged in a series, beginning with that having the least, and ending with that having the greatest combining number, many very remarkable points of connection are made manifest between the position of an element in the series and the general properties—physical and chemical—of that element. I shall point out one or two of these relations.

If the volumes occupied by masses proportional to the combining numbers of the elements be arranged in order, beginning with that element which has the smallest combining number, and if these numbers be compared with the combining numbers so arranged, it will be seen that the former numbers increase and decrease periodically with the latter. By representing the specific volumes—as they are termed—and combining numbers graphically by means of a curve, this periodic connection is rendered very manifest. Further, a connection is seen to exist between the positions of the elements on such a curve, and the physical properties of the elements. The more ductile metals are situated at the maximum and minimum points of the curve, or immediately follow those elements which are situated at these points. The more brittle metals are situated on the ascending portions of the curve, at no great distance from the points at which the maxima are reached. A relation also holds between specific volume, position on the curve, and volatility, between the same data and fusibility, &c. &c. Further, a close periodic relation is traceable between the combining numbers and the chemical properties of the elements.

The entire series of elements, arranged as described, may be subdivided into sections, and these sections are generally composed of elements bearing a close chemical analogy to one another. The valency of the numbers of many subsections increases and decreases periodically with changes in combining number and in specific volume. But it would be beyond the scope of this paper to discuss the bearings of the "periodic law of Mendelejeff" in detail. Suffice it to say that the "periodic law" evidently points to a quantitative connection between the combining numbers of the elements and the chemical (and many of the physical) properties of these bodies, and of their compounds.*

In the foregoing statements the combining numbers of the elements must be understood to mean those numbers which are based upon the two-volume formulæ of series of compounds, and which are checked by specific heat determinations, and by considerations of crystalline form.

The old equivalent numbers of the elements may be arranged in ascending order, but no general periodic connection can be traced between these and the properties of the elements.

The old chemistry refuses such generalisations as those which I have briefly indicated. It will have no dealings with two-volume formulæ, with numbers deduced from specific heat determinations, or from isomorphism; it traces no periodic connection between the numbers which it assigns to the elements, and the general properties of those elements. These things are called, by the old chemists, hypotheses; *their* system is founded on facts, and on facts alone. I suppose they mean to imply a very grave censure by the use of that word hypothesis. They seem to forget that all great advances in science have been made by the proper use of hypotheses.

But the old system does *not* confine itself to facts; else, why does it adopt 14 as the equivalent of nitrogen? why 6 as the equivalent of carbon? Why does it unite the equivalent of aluminium sulphate as $Al_2O_3.3SO_3$, when the true equivalent amount of this body is represented by the formula $Al_3O.SO_3$?

The old system deals in hypotheses as well as the new. There is, it is true, a difference between the hypotheses: the hypotheses of the old school are indefinite; they escape one when one attempts to lay hold of them; they do not admit of definite deductions being made from them. The hypotheses of the new chemistry are, for the most part, definite, workable, and allow of deductions being made from them, which deductions may be tested by an appeal to facts.

* In a paper entitled "On Chemical Classification" in the *Philosophical Magazine* for August, September, and October, 1877, I have gathered together in some detail the facts concerning this connection.

The new system tends more and more to bring chemistry under the sphere of general dynamics; the points of relation between chemistry and physics are every day being increased in number and in definiteness. The old system, in refusing the aid of those generalizations which I have briefly alluded to, tends to lessen the points of connection between chemistry and general physics, necessitates more or less the treatment of chemistry as a detached subject, and, in doing this, opposes the advance of that time when the grand idea of the unity of the sciences is to be realized.

The hypotheses, with the use of which the upholders of the modern school are taunted by their opponents, have done and are doing good work for chemical science. Has not the hypothesis of Mendelejeff necessitated the revision of the combining numbers of some of the rarer metals? and have not the recent determinations of the specific heats of these metals proved that the hypothetical numbers were more correct than those which were founded on facts (?)?

Has not the "periodic" hypothesis enabled Mendelejeff to predict the discovery of certain new elements, even to tell the probable properties of some of these elements? and has not the discovery of gallium at least rendered very probable the accuracy of his predictions?

Must we give up all these results? Must we return to mere empiricism? The difference between the old and the new chemistry is not a difference in the formulation of certain compounds; it does not consist in preferring certain numbers to certain other numbers: there is an essential difference in the fundamental methods of the two systems. To me it appears that the old system is empiric, the new scientific. Empiricism must precede science; but when we have attained to a certain degree of accurate knowledge, when we have gained a few far-reaching generalizations, to give up these and to return to isolated facts is, in my estimation, essentially opposed to the very nature of the scientific method.

I do not mean to assert that the new system is the best possible system; every day its defects are apparent. As chemistry advances, it is most evident that the system will require to be largely developed and perhaps, in portions, recast. Nor do I mean to deny that the old system has some points in its favour: there are reactions which can be more simply represented in terms of the old than in terms of the new notation. But I do think that the principles underlying the old system are principles which in their essence are opposed to true scientific advance, and that the principles underlying the new system are such as permit of great advances being made in the future, just as they have aided in the great advances of the past.

The new system seeks for as wide a basis as possible on which to rest the fabric of chemical science; the old system, by restricting itself to what it calls facts, narrows that basis so much as to render the fall of the whole structure not very improbable.

I have said that the modern system of notation is based upon two-volume formulæ, checked by specific heat determinations and by the study of crystalline forms: in many instances the specific heat and isomorphism methods are alone applicable for the determination of combining numbers. The numbers thus obtained express the (relative) amounts in which the elements enter into combination. We are justified in saying that oxygen always enters into combination in the proportion of 16 parts by weight, or a multiple of this number. It has been urged, by a distinguished chemist, that such a statement as this is not justified by the facts; that the amounts of oxygen occurring in two volumes of series of compounds are very nearly, but sometimes not exactly, multiples of 16; that the so-called law of multiple proportions has no existence apart from the atomic theory. Unless we found our notation on the theory that matter has an atomic structure and that chemical combination takes place between atoms, we have no right, it is argued, to say that the elements combine in multiples of certain fixed numbers. If the truth of the atomic theory be assumed, the "law of multiple proportions" must necessarily hold good. But it has been stated that we have no rigid experimental proof of the "law;" hence the conclusion is drawn that the atomic theory is a true theory. From the data I should rather conclude that the atomic theory is not a true theory. But I deny the data. We *have* sufficient experimental proof in favour of the generalization that the elements combine in certain fixed proportions by weight. The modern system of notation does not, I am convinced, necessitate the adoption of the atomic theory. In the preceding parts of this paper I have endeavoured to elucidate the main points of the old and new systems without referring to the atomic theory or using language which suggests such a theory.

I do not believe that we can develop a system of chemical notation (nor indeed any scientific system) which shall be absolutely free from hypotheses. The "law of multiple proportions" assumes that the apparent small divergences from the general statement which sometimes seem to occur are really due to errors of experiment. We must be content to make use of hypotheses in science; only we must test these by frequent appeals to facts, and we must always remember that they *are* hypotheses.

The combining numbers of the elements, then, generalize a great amount of knowledge concerning these bodies. But one naturally asks *why* do the elements combine in fixed proportions?

Why is there so intimate a connection between the numbers expressing the proportions in which the elements combine, and the general chemical and physical properties of these elements?

It seems hard to point out so many generalizations which may be made from facts, but to forbid us to generalize these generalizations. The molecular theory of matter—aided by the atomic theory of the chemist—professes to give some kind of explanation of the generalizations I have alluded to. And it appears to me that the rejection or acceptance of this theory must be based upon the success which attends its profession to give this explanation.

Matter, it is said, is possessed of a grained structure of some kind. A mass of matter is not a homogeneous whole, but is built up of parts, just as a brick wall is built up of individual bricks. These little parts are called molecules: when a body is heated the parts of the molecules do not part company. In chemical actions the molecules are split up; the smaller parts of matter then produced are termed atoms. Whether these are susceptible of further subdivision, or not, we do not know. From this theory certain deductions are made; very many of these deductions have been experimentally shown to be true. Among these deductions is the statement, generally known as Avogadro's law, that, "under the same conditions of temperature and pressure, equal volumes of gases contain equal numbers of molecules." Assuming the truth of this statement, it becomes very easy to determine the relative molecular weights of gaseous bodies. The weight of two volumes of hydrogen is the standard: this weight is called 2. The weight of two volumes of any other gas expresses the (relative) molecular weight of that gas. The smallest (relative) amount of an element occurring in one molecule—i.e. in 2 volumes—of any of its compounds is the maximum atomic weight of that element. In practice we generally assume this number to represent the true atomic weight.

The modern system of notation *may* therefore be regarded as an atomic notation. The two-volume formulæ become molecular formulæ; the combining numbers of the elements become atomic weights.

The constant number found by multiplying combining number into specific heat represents the atomic heat of the elements.

The crystal is a molecular structure, each compound molecule being built up of elementary atoms; the amount of one element which can replace an atom of another without altering the general form of the structure represents the weight of an atom of the replacing element. The fact that there exist intricate relations between the combining numbers and general properties of the elements receives some kind of explanation, when these numbers are regarded as the relative weights of the atoms of the elements.

The molecular theory teaches us to regard the molecule of a substance as a structure, as a definite whole. The old chemistry looked on chemical compounds as made up of two or more parts; it tended to the view that, when two substances unite, these substances are contained *as such* in the product of the combination. The old chemistry was always more or less a dualistic chemistry. The new chemistry rests upon a unitary basis. When two substances unite, the product is regarded as one new whole; the properties of the combining bodies are lost in those of the compound. Not that the compound is completely homogeneous; it is regarded as a structure, but yet a structure in which no one part is complete without every other, and in which the general properties of the whole are dependent upon the mutual action of all the parts. The new chemistry is, in this view of it, entirely in keeping with the molecular theory.

The introduction of the principle of substitution into chemistry led to the adoption of a unitary notation; such a notation finds a very probable explanation in terms of the molecular theory. The old equivalent notation has never been able to accommodate itself to the requirements of the unitary system; it does not find its fullest explanation in, but is rather opposed to, the idea of a molecular structure.

The molecular theory of matter is adopted by the great majority of physicists as a good and workable scientific hypothesis; the physicists find that this theory enables them to group together and to explain a greater number of facts than can be brought within the grasp of any other theory concerning the structure of matter which has yet been propounded. And is it not of the utmost importance that the fabric of chemical science should be reared from a foundation upon which rests also the whole building of natural philosophy?

Chemical facts, as well as physical facts, can be explained most fully in terms of the molecular theory: the new chemistry recognizes this; the old chemistry passes it by. Chemistry tends more and more to become a branch of dynamical science. To reintroduce the old equivalent system of notation would, it appears to me, be to render more distant the arrival of the time when it shall be possible to treat the science of the dynamics of atoms as a branch of the larger science of the dynamics of molecules.

But, nevertheless, the old system has some points in its favour; it has had—it still has—many great names identified with it. If it be really better than the new, it will again become paramount. What the investigators of Nature seek is not systems, but truth. Why, then, should we quarrel with one another?

THE GEOLOGICAL ANTIQUITY OF FLOWERS AND INSECTS.

By J. E. TAYLOR, F.G.S., &c.

NO naturalist will deny that, in every period of the earth's palæontological history, the animal and vegetable kingdoms have been correlated, no matter how lowly organized they may have been. But if the geological record is imperfect as regards the *animal* life which has peopled our globe during past ages, none will be surprised that it should be considerably more so as regards extinct *vegetable* types. The chances are infinitely against the preservation of the latter in sufficient perfection to enable modern botanists correctly to make out their relationships. The earliest plants were formed of loose vascular and cellular tissues, which readily decomposed, and were therefore difficult of fossilization. Plants do not possess such hard and comparatively indestructible parts as the majority of animals have, as teeth, bones, tests, and shells. Only a few plants have external substances capable of resisting decomposition, but such species rank low in the scale of classification, as in the case of the *Diatomaceæ*, which possess siliceous frustules or valves. The horse-tails (*Equisetaceæ*) are remarkable among plants by the large quantity of silica which enters into the tissue of their exterior; and in this respect they resemble many of the grasses, notably such gigantic species as the bamboo.

With the exception of the *Algæ*, or sea-weeds, plants are chiefly terrestrial in their habits. Even those flowering plants we call aquatic, generally grow at the margins of the land or in shallow water. The number of true flowering plants, such as *Ruppia* and *Zostera*, which live in brackish or salt-water is very few. Consequently geologists are dependent for the preservation of plants upon fewer physical possibilities than those which allow animal remains to be fossilized. Only where an extensive lake has had sediments quietly forming along its bottom, or in the estuary of some large and not too turbulent river, has it been possible for plants to be mineralized;

and it is in lacustrine and estuarine deposits that we find vegetation most perfectly and abundantly fossilized. On the other hand, every geological formation abounds more or less in animal remains; chiefly those of marine species which lived in the seas along whose floors the rocks were originally laid down in the sedimentary state. In estuarine and lacustrine strata we meet with the largest number of remains of land animals. Their carcases have been brought down by streams and rivers. The proportion of land animals thus preserved, both vertebrates and such invertebrate forms as insects, bears a certain proportion to the number of actual terrestrial plants which have also been fossilized.

If therefore the geological record is imperfect as regards fossil animals, most of which were marine, it must necessarily be so as regards plants. As to their bearing on the doctrine of evolution, less than ten years ago some of our best naturalists held that fossil animal remains were neutral. So little dependence could be placed on any inference drawn from their geological distribution, owing to the possibility of their unexpectedly being found in other strata than those to which it was supposed they had been limited, that philosophical naturalists preferred to regard palæontological evidence for the time as *nil*. But year after year has witnessed the discovery of new animal forms in strata of various ages, and in different parts of the world; and now the most stubborn opponent of evolution is obliged to acknowledge that the balance of evidence from fossil remains is becoming every day larger in favour of the new philosophy.

Much the same may be said of fossil botany. Thanks to the value of mineralized vegetation when it assumes the shape of coal, the formations bearing it have been better studied and explored than any other, so that the chances of finding new vegetable forms have been greatly increased. We have sometimes to skip formation after formation before we can accept any inference drawn from the occurrence of fossil land plants, and we are often surprised by the contrasts between floras thus separated by extensive epochs. Thus, after the abundant flora of the Coal Measures, we meet with but little until we come to the Upper Cretaceous, Eocene, and Miocene formations. Here and there in the Lias, some parts of the Oolite, and the Lower Cretaceous rocks, we come upon local floras, some of which, as in the case of the Upper Cretaceous floras, had an extensive geographical distribution, so that any inferences drawn from their occurrence are much safer than if we had met with a fossil flora in one locality only. Whereas in the animal remains of the successive formations we can witness group after group of marine organisms making their appearance and becoming extinct, the story of the vegetable

life of the globe is interrupted by enormous periods of time. This is due to the fact that the greatest number of the rocks with which geologists are best acquainted were formed in seas far from land, where it was impossible for land vegetation to be carried without destroying its distinguishing characters.

Notwithstanding this "imperfection," however, there are certain broad and unquestionable principles which geologists can depend upon in the succession both of animal and vegetable types. Thus we find that the simplest forms appear in the oldest formations, and the most complex and highly organized in the latest. No investigation appears likely to disprove this most important fact. Again, as regards animals particularly, and, far as can be ascertained, with plants also, the most *generalized* types of organized objects precede the *specialized* forms. If we had as good means of identifying plants from fragments as we have in the case of the higher animals, there can be little doubt we should find the same truth holding equally good in the vegetable kingdom. Modern naturalists have made some important discoveries by the light of embryology—that is, of the probable descent of any species by tracing the successive changes which it may pass through as an embryo. In this way it is found that the embryo of a mammal passes through an enormous number of stages, from those representing single-celled infusorial animalcules upwards and onwards through others corresponding to fish, amphibian, reptile, and bird. These embryonic stages are a kind of condensed evolution, taking place and succeeding each other in a few months instead of in millions of years, and occurring in the life history of one animal instead of an incalculable series. Embryology therefore is regarded as illustrative of palæontological evolution.

But here again animal structures give a greater advantage to the student of their history and relationships than plants. The latter have fewer embryological stages through which we can trace their probable lines of descent. This has been attempted by a few English and German naturalists, and with considerable success, but the subject remains an almost unworked field. The most suggestive probabilities as to the origin of some of the leading orders of flowering plant come from a quite unexpected quarter, namely, their monstrosities or teratology. Thus, we find that frequently the *abnormal* conditions or monstrosities of one order of plants correspond to and assume many of the characters distinctive of another order. In this way it is possible some orders may have arisen through adventitious changes in structure brought about by changes in the physical surroundings, such as climate, moisture, and height above the sea-level.

The correspondence in the mode of succession of animal and

vegetable remains, as everywhere revealed by the study of geology, renders it very probable that we have hit upon the true order of appearance on our globe. Such terms as were used by the older geologists, as the "age of fish," the "age of reptiles," and "age of mammals," roughly express this method of succession. And beyond modifications in the hard and fast lines where they made these animals to come in or disappear, nothing has been discovered to interfere with the arrangement. Corresponding to this was the classification of the vegetable kingdom, based on fossil remains, founded by Brongniart many years ago, of the "age of acrogens" (or ferns), "age of gymnosperms" (or conifers), and "age of angiosperms" (true seeding-plants). In both kingdoms, animal and vegetable, there is the strongest evidence—evidence which every new discovery strengthens—that the lower preceded the higher, and the general the special forms.

Brongniart's simple classification of the geological order of succession of the three most prominent of vegetable types upon the earth, ought not to lead the student to infer that during the "age of acrogens" or ferns, there were no conifers, or that, when the "age of gymnosperms" prevailed, there existed no true seeding or angiospermous plants. The classification indicates only the prevailing groups of vegetation. These can be again divided, so that we find the order of classification corresponds to that of palæontological succession. Thus up to the conclusion of the Silurian period, sea-weeds or *algæ* were the dominant types of vegetation; from the upper Silurian to mid-Carboniferous times, ferns and club-mosses (*Lycopodiaceæ*) were most abundant. In the Permian and Triassic periods coniferous trees were in the ascendency; then follow monocotyledonous plants, such as palms and grasses in the Oolite, and true flower-bearing plants in the Lower and Upper Cretaceous; with abundance of them in the Eocene, a preponderance of them in the Miocene strata, and so onwards to our own time. Even among the true flower-bearing or phanerogamous plants, we find that the monocotyledonous preceded the dicotyledonous; whilst the wind-fertilized (*anemophilous*) groups of dicotyledons appeared before the insect-fertilized (*entomophilous*), certainly as orderly as the Acrogens came before the Gymnosperms. For the occurrence of a few insect-fertilized plants among the first dicotyledonous flora no more invalidates this conclusion than does the fact that we find coniferous trees in the Devonian rocks interfere with their existing in the so-called "age of acrogens."

It has been recently shown that the colours of petalled or perianthed flowers exist in the first place because they are useful to plants in attracting insects; and that the visits of insects thus secured, cause pollen to be carried from one plant to another,

and so produce that degree of crossing which is beneficial. It has been found that the size and colour of the corollas of flowers (as in the geraniums), the intensity of their perfumes, or the (more practical) larger amount of honey which may be secreted in their nectaries, are always proportioned to the needs of the flowers to be crossed by pollen other than their own. So necessary is this crossing in some instances that the pistil of a flower is as barren when dusted with pollen from its own stamens as if it had been fertilized with pollen from an altogether different species. It had long been acknowledged in a general way that flowers were necessary to insects; but it is only within the last few years that it has been discovered that insects are quite as necessary to flowers. With the exception of accidental crossing, which may result from such fringe-winged insects as the minute little *Thrips* to be seen in most English flowers, the insects which can fertilize or cross different flowers, so as to make their visits important and serviceable, are limited to two or three orders. Of the orders of insects now recognized by zoologists, one may be regarded as specially adapted to flowers. This is the order Lepidoptera, a peculiarly flower-haunting group all over the world, both in the day-flying species called butterflies, and the night-flying species known as moths. Their mouths are in the shape of a trunk or proboscis, which does not allow them to suck food except in a fluid state, such as that in which we find the natural honey of plants. To this universal fact of the Lepidoptera being purely suctorial, there is only one exception in the case of the curious moths in Australia (*Ophideres*), which have boring or terebrant mouths; thus linking the Lepidoptera with other orders of insects. Next to the Lepidoptera in importance to flowers as an order, are the Hymenoptera, of which, however, only the bees are purely flower-frequenters; a good many members of this order being even disadvantageous to flowers. Among them we may instance the numerous species of ants, whose fondness for the honey secreted by flowers induces them to climb the stems of plants for the purpose of obtaining it. But as these insects are *wingless* (except a particular set at a certain time of the year, when flowers have nearly all bloomed), and as their bodies are glossy and bare of the hairy covering which in butterflies, moths, and bees enables the pollen to stick to the body, it follows that ants cannot be serviceable to flowers in crossing them; whilst if they steal the honey offered as a reward to serviceable insects, they are so far actually enemies. It is to protect flowers against such predatory excursions as those made by vigilant ants that their stems are covered with hairs and prickles, or gummy with viscid secretions. Some of the Coleoptera or beetles, such as the rose-chafers, and various

small species, are of advantage to flowers by carrying away the pollen which attaches itself to the underside of their bodies during their slow and sleepy foraging in the bosom of flowers. A few Diptera also may be useful to plants in crossing them. But enough has been said to prove that the Lepidoptera first, and such specialized forms as the bees among the Hymenoptera second, are the members of the insect world on which flowers most depend for being effectually crossed.

Now, if among all the vegetable productions of the globe those plants which bear conspicuous and attractive flowers are the latest to appear (as we have seen they are, the *anemophilous* group preceding the *entomophilous*), then, as the *Lepidoptera* are so absolutely necessary to the perfect crossing of plants, they ought to make their appearance about the same time. That is to say, if true flowers are the latest of all the developments of the vegetable world, butterflies and moths ought to be the latest evolved among the insect-tribes. Remains of insects have been found fossilized in deposits as ancient as those of the Devonian period, and from that time onwards to our own, under conditions which would have equally admitted the preservation of Lepidoptera had those insects been then in existence. It must not be imagined that, in spite of their gay colours and attractive appearance, we regard butterflies and moths as the most highly organized types of insects. On the contrary, bees, ants, and wasps among the Hymenoptera, and termites, or white ants, among the Neuroptera, by their subtle display of instinct, their knowledge of the division of labour, and the general mode in which they conduct the affairs of the hives or republics in which most of them live, recommend themselves to our notice as cerebrally the highest endowed of all forms of insect life. But the Neuroptera and Hymenoptera were in existence ages before the appearance of moths and butterflies, although it is not until the tertiary period that we find them fossilized in such specific forms (termites and ants) as leads us to believe their marvellous instincts had even then been established.

We have seen how it is possible to trace in few words the general order of succession of the leading types of animals, and also of plants. Sir John Lubbock and other philosophical entomologists believe that the various orders of insects came into existence, at different periods, somewhat as follows:—*Orthoptera* and *Neuroptera* in the Devonian epoch; *Coleoptera* during the Carboniferous; *Hymenoptera*, *Hemiptera*, and *Diptera* during the Oolitic and Cretaceous periods; and *Lepidoptera* not until Tertiary times set in. The remains of a supposed fossil butterfly have been found in the English Oolites, and named by Mr. Butler *Palæontina oolitica;* but the lepidopterous

character of the single wing thus named is doubted by Mr. S. Scudder in his work on fossil butterflies. Two other supposed secondary butterflies have been criticized by the latter author, one of which specimens he has personally examined and declared to belong to another order; and the other, which he has not seen, he does not think is lepidopterous. This examination leaves Lubbock's generalization true, for the present, that the Lepidoptera only appear in Tertiary strata. We see no reason, however, why they should not have appeared earlier, say at the beginning of the Cretaceous epoch, when true flower-bearing plants first made their appearance, although the first flowers may have blossomed more for Hymenoptera than Lepidoptera; and, indeed, the fact that the first flowers were polypetalous rather than gamopetalous—that is, had corollas made up of separate petals, rather than of the petals all joined together as we find them in the common blue-bell (*Campanula*)—is an indication that gamopetalous flowers could only be formed when there were insects with proboscides long enough to be thrust down to the nectaries at their bases, as we find them in butterflies and moths.

Thus we see there is a broad parallelism between the appearance of the more differentiated types of the vegetable kingdom, and the development or appearance of various orders of insects. Instead of the appearance of a new order, the differentiation may have been accompanied by such specialization of a large group as the bees among Hymenoptera. Mr. H. Goss has published three very important papers on the insect fauna of the primary, secondary, and tertiary periods, in which he has given the proportion of species. Of these we observe the Coleoptera or beetles are best represented. It is one of the most extensive in its geographical distribution—a fact which always indicates the antiquity of organic forms, as it proves they were spread before those physical geographical changes occurred which give the surface of the earth its present features. Among the beetles, also, we find a very extended differentiation; their genera are adapted to almost every habit of life, aquatic, subterranean, and terrestrial. They are aborted as well as developed, as in the case of the glow-worm. They live on carrion, fungi, pollen, nectar, wood, leaves, and other organic substances, and have their structures modified accordingly. Hence we cannot be surprised that the Coleoptera seem to have been from the first a dominant order, seeing how useful beetles have made themselves in the economy of the globe. Perhaps also the durability of their hard wing-cases (*elytra*) has frequently enabled them to be fossilized when other insects would have been decomposed, and thus caused them to appear numerically more abundant than contemporary orders.

We find the general distribution of insects, in geological time, to be in the order we should expect from what has already been said. The oldest fossil insect is termed by Nicholson *pseudo-neuropterous*—a name which indicates its generalized character. This occurs in the Devonian rocks of North America, but the large size of wing of one of these fossil species (indicating an expanse of five inches) leads us to infer that these Devonian forms cannot be the oldest of winged insects. Mr. Scudder regards this earliest known insect as a "synthetic type"—that is, one which combines peculiarities of structure now distributed and specialized in different groups. In the Carboniferous rocks many species of fossil insects have been met with. Among the Neuroptera we have a member of the *Ephemeridæ* or "May-flies" larger than any now known, having an expanse of seven inches of wing. These are insects which pass the first stages of their existence as aquatic larvæ. The Orthoptera are represented by very generalized forms of cockroaches, crickets, and locusts. Beetles, however, are not yet so abundantly preserved.

In the Secondary rocks large numbers of fossil insects have been found, and here beetles take the leading place. One great storehouse for them is the Lias bed at Schambelen, Switzerland. In England the Rhætic beds have yielded a rich harvest, as may be seen by a reference to the work on British Fossil Insects by the Rev. P. B. Brodie. The Purbeck beds are also locally productive of many fossil species. No *Hymenoptera* have been yet found in the Rhætic beds; but 29 species of *Coleoptera*, 12 of *Neuroptera*, 9 *Hemiptera*, and 7 *Orthoptera* from these strata have been described. Two species of beetles have been found fossilized in the Swiss Trias. Prof. Heer has discovered in the Liassic rocks of Schambelen no fewer than one hundred and forty-three species of fossil insects, which are distributed as follows: *Coleoptera* 116 species, *Hemiptera* 12, *Hymenoptera* 1, *Orthoptera* 7, and *Neuroptera* 7. The fossil beetles had even then been specialized into carnivorous types: others were leaf-feeding beetles. Some evidently lived on decaying wood; but as yet there were none which are now known to haunt flowers.

In the Stonesfield slate of England various fossil insects have been discovered. They are represented by large species of *Neuroptera*, such as dragon-flies, and various well differentiated genera of *Coleoptera*, already adapted to different kinds of food and habits of life; but none of them are flower-frequenters. It was in this bed that the supposed fossil butterfly called *Palæontina oolitica* was met with. If this be a true butterfly there must have existed flowers at the time when the Stonesfield Slate was formed, according to the theory that flowers and Lepidoptera go together. The Purbeck beds were formed in a large

lake, and under conditions such as are favourable to the preservation of insects; and accordingly large numbers have been obtained from this interesting formation. The orders *Diptera*, *Orthoptera*, *Neuroptera*, and *Hymenoptera* are abundantly represented by fossil gnats, cockroaches, dragon-flies, and huge ants allied to exotic genera. Out of sixty-four species described, the beetles number eighteen. The hemipterous insects follow next, with fourteen species; the *Diptera* with thirteen, and the *Orthoptera* with ten. The beetles are chiefly herbivorous kinds.

When we come to the Tertiary strata undoubted Lepidoptera make their appearance. There is no longer any zoological doubt as to what they are. But this is the period when true flowers began to be abundant, and therefore it is significant we should find specialized flower-loving insects appearing at the same time. As a rich fossil flora, containing true flowers, has been found in formations as old as the Lower Cretaceous in Greenland, it is possible that Lepidoptera appeared before the Eocene period. Nine species of fossil butterflies are found in strata of the latter age at Aix in Provence. The Miocene strata of Switzerland have yielded an immense number of species of fossil insects, which have been described by Professor Heer. In beds of this age at Radoboj in Croatia, three species of butterflies have been found; one of them singularly allied to an Indian species. In this formation the Hymenoptera are very abundant. From the Swiss Miocene at Œningen Professor Heer has obtained nearly nine hundred species of fossil insects, of which the Coleoptera number no less than five hundred and eighteen. Not only do we find these Miocene beetles differentiated and adapted to all the habits of life which their Oolitic predecessors had already possessed, but for the first time we come across true *flower-haunting* beetles, belonging to groups actually specialized in our own day to particular genera of flowers. So striking is this that Professor Heer infers the existence of such flowers (although they have not as yet been found) during the Miocene epoch. The fossil Hymenoptera of Œningen number *eighty* species, and among these are those highly specialized forms, such as bees, which are always associated with flowers. Three species of butterflies are all which have as yet been recognized. It would seem probable, therefore, that bees appeared before butterflies, and obtained their remarkable specialization by being adapted to the earliest of the flowering plants.

Near the White and Green Rivers, bordering on the territories of Utah and Colorado, an immense tertiary deposit has been explored by the United States surveyors. Its shales have been found crowded in places with insect remains, including even the

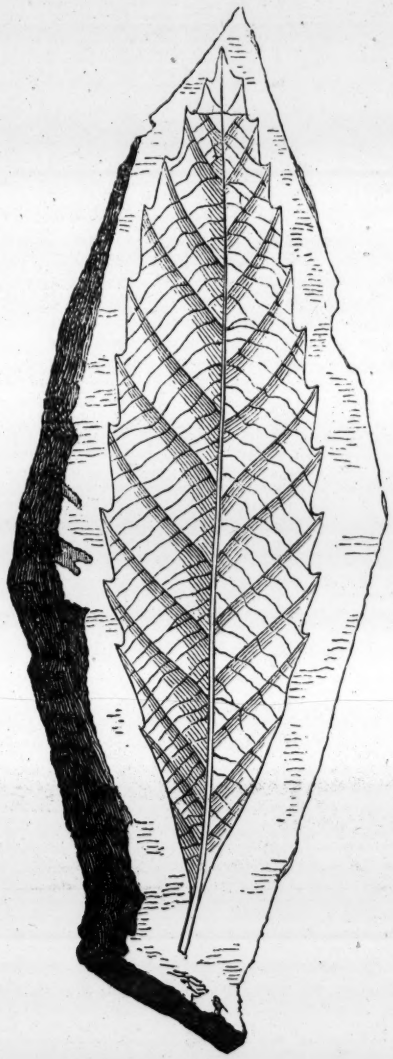
larvæ. One species of *Thrips* has been found whose minute fringed wings, characteristic of its order, are visible under the microscope. Fossil ants occur here, so that their peculiar specialization had already been effected. Only one species of moth, however, has hitherto been met with out of the sixty or seventy fossil insects described.

Later tertiary beds always contain fossil insects where the conditions are favourable to their preservation; but it would appear as if all the great orders had assumed their modern distinctiveness before the close of the Miocene period. What has since occurred has been chiefly their changed geographical distribution, and the breaking up and differentiating of two of the orders, Hymenoptera and Lepidoptera, so as to adapt many of the species of each to the most abundant or most frequented of the flowers where such insects have been distributed.

We see that a comparison of the order in which insects have appeared leads us to infer the absence of true flowers until the later geological epochs. A parallel development has taken place in insects and flowers during geological times, so as to slowly and mutually adapt each to the other. The order in which the various families of flowering plants have appeared bears a relation to that in which the different groups of insects have succeeded each other. Thus we have first the conifers and cycads, wind-fertilized plants, producing a superabundance of pollen so that some of it may surely take effect. The grasses and sedges probably appeared during the Triassic, Liassic, and Oolitic periods, although in no very great abundance or variety, or we should have more fossil remains of them than we have in the doubtful *Cyperites*. The *Antholithes* of the coal measures, once believed to be a grass, is now known to be merely a fruit-bearing spike of some coniferous plant. During the "age of conifers" a large differentiation took place in this order. There were coniferous trees living during the Carboniferous period which bore adiantum-like leaves, similar to those still produced by the peculiar conifer from Japan known as *Salisburia*, and "stone fruit," almost like plums, or rather resembling the fruit of the yew, which has long been familiar to geologists under the name of *Trigonocarpum*. These fruits are found in such abundance in some sandstone beds of the Upper Coal Measures as to make them appear almost composed of nothing else. Pines with the ordinary needle-shaped leaves, and cone-bearing, have always been abundant. The fossil plant known as *Pothocites*, found in the Scottish Coal Measures, and supposed by Carruthers to be the spike of an aroideous species, is imperfect, and some botanists deny its phanerogamous character altogether. Only eighteen species of fossil monocotyledonous flowering plants are recorded as having been dis-

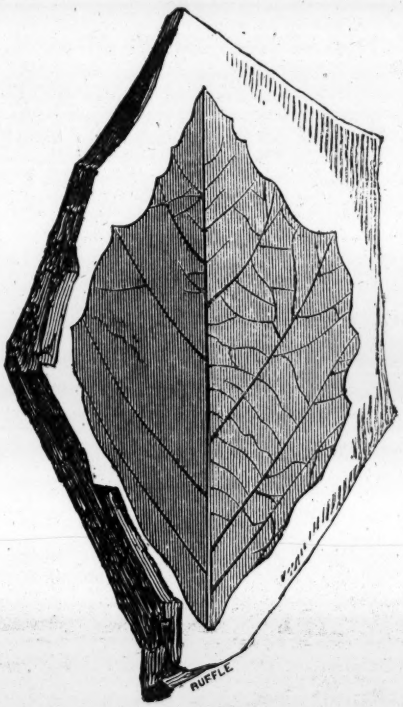
covered in the three formations Trias, Lias, and Oolite, and some of these are doubtful. This proves how very scanty must have been the flower-bearing flora, for we get no similar poverty of fossil ferns or conifers. The Wealden formation was deposited as a delta at the mouth of a large river—a river watering an enormous area of country, which must have been

FIG. 1.



QUERCUS PRIMORDIALIS, UPPER CRETACEOUS BEDS, DAKOTA (after Lesquereux).

FIG. 2.



BETULA BEATRICIANA, UPPER CRETACEOUS BEDS, DAKOTA (after Lesquereux).

more or less covered with plants; and the Purbeck beds were formed along the floor of an extensive fresh-water lake. No conditions could have been more favourable for the preservation of land plants than these, yet the number of flowering

species is extraordinarily small. Remains of insects, their wings, legs, heads, &c., are preserved as we have seen; and there is no reason why we should not have found dicotyledonous flowering plants had they been abundant.

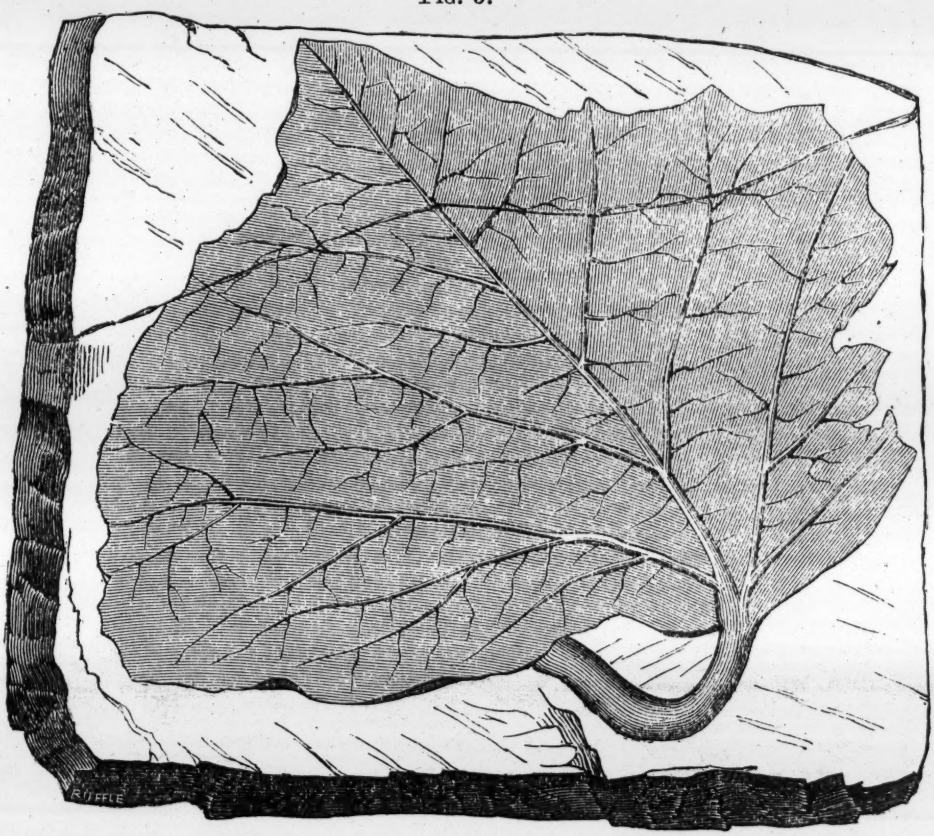
In a Greenland formation which Professor Heer calls *Lower* Cretaceous, plant beds are found which have yielded extraordinary results; 138 species of ferns, 75 of monocotyledonous flowering plants, and one dicotyledonous plant have been described. In the greater part of Europe the Cretaceous period was marked by deep-sea conditions, so that we have little expectation of finding fossil land plants. The *Upper* Cretaceous formation in many places seems to have been favourably deposited for the preservation of these desirable plants. It should be stated, however, that in the opinion of some geologists some of the so-called "Upper Cretaceous" beds, especially those of Dakota, are regarded as possibly intermediate in age between the Cretaceous and Eocene, so that they form "passage-beds" between the Secondary and Tertiary epochs. The most remarkable strata of these deposits are perhaps those of Dakota in the Western States of America, whose fossil plants have been figured and described by Professor Lesquereux. Here we find no fewer than one hundred species of dicotyledonous plants. In the Aix-la-Chapelle beds a large number of fossil leaves, &c. have enabled botanists to chronicle the incoming of many orders of plants at an earlier date than had been before imagined. In tropical Africa and Greenland plant-bearing beds of so-called Upper Cretaceous age have also been explored; and the occurrence of the remains of monocotyledonous and dicotyledonous plants in them proves how widespread and abundant these groups had already become.

All the coniferous and most of the monocotyledonous plants are "wind-fertilized"; and it is probable that up to the beginning of the tertiary epoch no such beautiful perianthed monocotyledons as the lilies, tulips, &c., had made their appearance —that, in short, all the monocotyledonous plants were up to that time "wind-fertilized." It is curious to note that when the dicotyledons first make their appearance it is also the "wind-fertilized" group which comes first. Thus, in the Upper Cretaceous beds of Dakota, out of the one hundred species of dicotyledonous plants described, no fewer than sixty-one are *apetalous*, such as the oaks, maple, &c. (see figs. 1 & 2). Many of them were catkin bearers, as the poplars. Of the remainder, thirty-five species are those possessing *polypetalous* flowers; whilst only *one* species is *gamopetalous*—that is, has flowers with the petals united into one piece. The proportion of "wind-fertilized" over "insect-fertilized" plants is always greater the further we go back in geological time, thus indicating that the "wind-

fertilized" appeared first. If we could get specimens of the entire plants, and were not forced often to depend on leaves alone for the identification of genera, there can be little doubt we should find the earliest dicotyledonous plants to belong to much more generalized types than any now existing. Such is the opinion of Baron von Ettingshausen, who has studied and compared the cretaceous and tertiary floras of the world.

The order of floral occurrence therefore is 1st, "wind-fertilized" or *anemophilous* Monocotyledons, such as grasses, sedges, rushes, &c.—gay-flowered or *perianthed* Monocotyledons not appearing for certain until the Miocene period; 2nd, Dicoty-

FIG. 3.



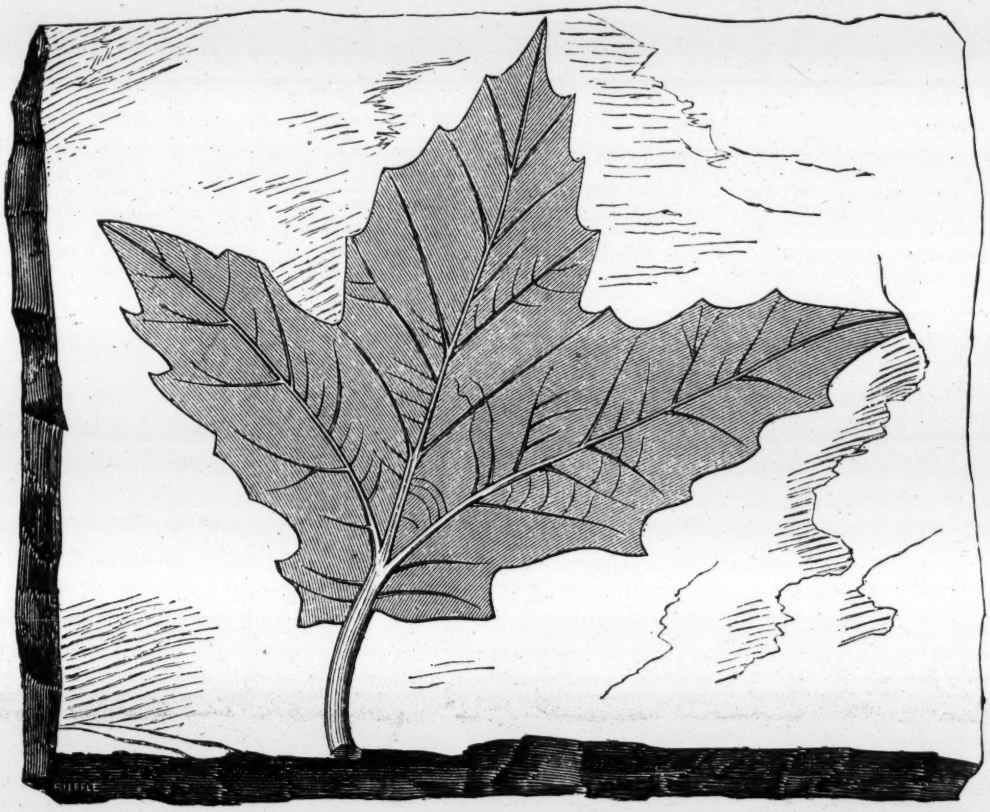
POPULUS LATIOR, UPPER MIOCENE, ŒNINGEN. From a specimen in the Ipswich Museum.

ledons belonging to the "wind-fertilized" division, and bearing inconspicuous flowers or catkins; 3rd, Dicotyledons with *true* flowers, but having the flowers composed of several pieces or petals (*polypetalous*); and 4th, Dicotyledons in which the petals are united, so that the flower or corolla is in one piece (*gamopetalous*). Of the *Gamopetalæ*, the *irregular* flowers, such as those of *Labiatæ*, *Scrophulariaceæ*, &c., were developed later still. The showy irregular perianthed flowers, such as Orchids, also

appeared among the later floral developments. This is certainly their order of numerical proportion, and we have little doubt it is also that of the actual succession and appearance in time of flowering plants.

The Tertiary epoch is that which up to a few years ago was believed to have first witnessed the introduction of dicotyledonous plants. We have seen that this is not the case. But as we should expect from the line of argument employed, their number becomes numerically greater as we approach the present

Fig. 4.

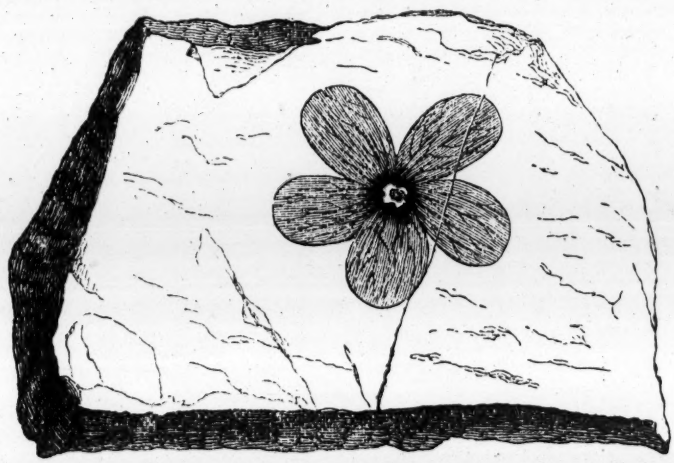


ACER TRILOBATUM, UPPER MIOCENE, ŒNINGEN. From a specimen in Ipswich Museum.

era. The Eocene beds of Hampshire and elsewhere have yielded abundant remains of a flora of a nearly tropical character, but which is on the whole related to that found in the older so-called "Upper Cretaceous" formations of Aix-la-Chapelle and America. The Eocene plants include many genera now deemed peculiarly Australian, such as the *Proteaceæ*; smilax, dryandras, acacias, azaleas, cactuses, aroids, figs, &c. abounded; and their remains are found fossilized with those of fan-palms, feather-palms, and others. Climbing plants and llianes then festooned the forest trees, as they now do the woods of the West Indies.

It is in the Miocene period, however, that we have the remains of the most wonderful flora preserved, especially in the molasse beds of Switzerland. From its warm temperate character, Prof. Heer thinks the climate must then have been about sixteen degrees higher than it is now. One peculiar feature about the Miocene flora is its assemblage of existing genera which have since been rendered locally extinct, so that we now find them in parts of the world at immense distances from each other. This has been greatly the result of subsequent geographical changes, some of which, such as those occurring in the glacial epoch, were of an extraordinarily rigorous character. No fewer than seven hundred species of fossil phanerogamous plants have been obtained from the Swiss Miocene beds alone. Of these nearly three hundred were trees, and two hundred and fifty shrubs. One hundred and sixty species were herbaceous

FIG. 5.

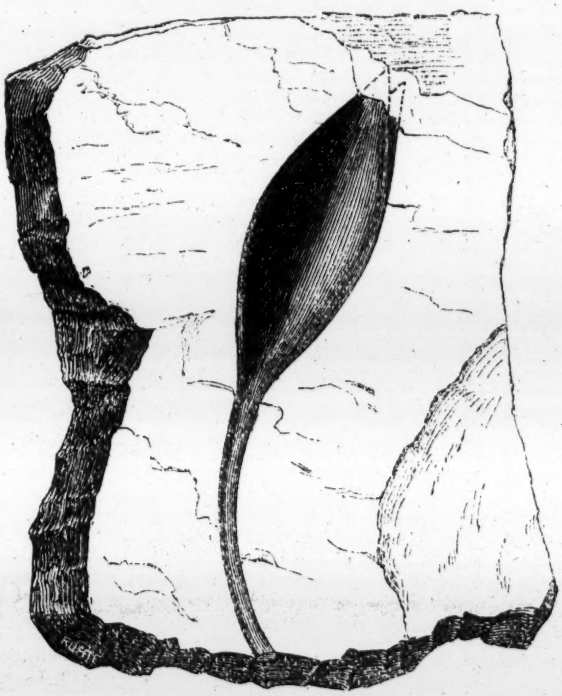


FOSSIL FLOWER (*Parana œningensis*), UPPER MIOCENE, ŒNINGEN.
From a specimen in Ipswich Museum.

flowering plants; many of them grasses and sedges, others with showy blossoms or corollas (fig. 5). The Miocene flora plainly shows us that a great differentiation had taken place in the form and grouping of insect-fertilized plants since they first appeared. We now meet with *Composite* flowers, where we have an abortion of some and a specialization of other florets, all diminished in size and peculiarly arranged on a disk, so as to suggest the popular idea that the whole colony is only one flower, as is certainly the notion with the daisy, dandelion, and sunflower, &c. Such a modification of floral parts would only be expected by a botanist in periods subsequent to the first appearance of these flowers, and he regards them as produced by a gradual modification. *Papilionaceous* flowers, like those of the pea, remarkable for the different sizes and shapes of the petals and their different

colours—rarely the same in any two genera—abound in the Miocene beds. There are traces of them in the Eocene, where a nearly allied group, the *Mimosas*, resembling them in the construction of their fruits (*legumes*, fig. 6) are not uncommon. Water-lilies covered the quiet surfaces of Swiss and English lakes during the Miocene period as they do in our own day. Cinnamon trees (now characteristic of the far East) abounded, Proteaceous plants (at present peculiar to the Southern Hemisphere) grew by their side, magnolias and tulip trees (well-known American forms) sprang up in botanical fellowship. In company with them were almond trees, plum trees, hawthorns, and many others familiar in temperate regions.

FIG. 6.



FOSSIL FRUIT (*Podogonium Knorrii*), UPPER MIOCENE, ŒNINGEN.
From a specimen in Ipswich Museum.

The Pliocene and Glacial periods witnessed the local extinction of many of the plants whose more generalized character enabled them to grow together during Miocene times, and the geographical distribution of others to the areas they now occupy. In a great measure the entomophilous flora has been otherwise specialized since then—many plants have become *monœcious* or *diœcious*, dimorphic and trimorphic, cleistogamous or otherwise aborted. These changes are still going on, and the appearance of man has done not a little to add to the disturbing agents in the floral equilibrium of the world. We have seen

that the appearance in geological time of the most beautiful or sweetly perfumed flowers is also that of the insects which now habitually frequent flowers. And as the wind-fertilized precede the insect-fertilized flowers in order of geological time, we contend that the latter may have been modified out of the former. Not unfrequently the same genus of plants contains both insect- and wind-fertilized flowers, as in our own common ash (*Fraxinus excelsior*) which is apetalous, and the species naturally abundant in the South of Europe, and now in our ornamental shrubberies, which possesses a corolla, and is therefore insect-fertilized (*F. ornus*). It is not to be concluded that the plants which bear the most beautiful flowers are the most highly organized, any more than such specially attractive insects as the Lepidoptera are also the highest in point of organization and development. Some of the Neuroptera, such as the white ants (*Termites*), and many among the Hymenoptera, as bees and ants, are more cerebrally developed. We have therefore a peculiar aspect of evolution here presented, not necessarily towards *higher* organization, as some people think is imperative in the new philosophy, but in the direction of special adaptation to each other's necessities and well-being on the part of two groups of organisms having no other connection with each other than that of having become mutually adapted to each other's requirements.

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

THE interest which attaches to the history of extinct British animals can only be equalled by the regret which must be felt, by all true naturalists, at their disappearance beyond recall from our fauna. It seems almost incredible that the number of wild animals which have become extinct in the British Islands should equal, if it does not exceed, the number of the still existing forms with which we are familiar. And yet if we exclude from consideration the Chiroptera and the marine mammalia, this is not far from the truth.

Naming them at random, and commencing with the largest, the extinct British species are—the mammoth, elephant, rhinoceros (two, if not three species), hippopotamus, primæval ox, longfronted ox, aurochs, musk ox, Irish elk, reindeer, wild boar, brown bear, grizzly bear, great cave bear, lion, sabre-toothed lion, leopard or panther, hyæna, spotted hyæna, lynx, wolf, arctic fox, glutton, beaver, lemming, crane, and bustard. The *ferœ naturœ* still existing in Great Britain are—the red deer, the roe deer, fallow deer (introduced), wild white cattle, the hare, Alpine hare, rabbit, hedgehog, mole, shrew (three species), badger, otter, weasel, stoat, polecat, common marten, pine marten, wild cat, fox, squirrel, dormouse, harvest mouse, long-tailed field mouse, house mouse, black rat, brown rat, water vole, short-tailed vole, and bank vole.

One of the few wild animals which survived to within historic times, and hence one of the last to disappear, was the wolf, a creature whose ferocious and bloodthirsty nature caused it to be speedily singled out for extermination by the early English legislators.

To judge by the osteological remains which the researches of geologists have brought to light, there was perhaps scarcely a county in England or Wales in which, at one time or another, wolves did not abound, while in Scotland and Ireland they must have been even still more numerous.

The vast tracts of unreclaimed forest land which formerly

existed in these realms, the magnificent remnants of which in many parts still strike the beholder with awe and admiration, afforded for centuries an impenetrable retreat for these animals, from which it was well-nigh impossible to drive them. It was not, indeed, until all legitimate modes of hunting and trapping had proved in vain, until large prices set upon the heads of old and young had alike failed to compass their entire destruction, that by cutting down or burning whole tracts of the forests which harboured them, they were at length effectually extirpated.

In the course of the following remarks it is proposed to deal, first, with the geological evidence of the former existence and distribution of wolves in the British Islands; secondly, with the historical evidence of their survival and gradual extinction.

Under the latter head it will be convenient to arrange the evidence separately for England and Wales, Scotland, and Ireland: and, as regards England and Wales, to subdivide the subject chronologically into (1) the Ancient British period; (2) the Anglo-Saxon period; and (3) the period intervening between the Norman Conquest and the reign of Henry VII.

In this reign, it is believed, the last trace of the wolf in England disappeared, since history thereafter is silent on the subject. In Scotland and Ireland, however, this was by no means the case, as, later on, we shall have occasion to show.

Geological Evidence.

Owing to the great similarity which exists between the skeleton of a wolf and that of a large dog, it is sometimes extremely difficult for any but a good anatomist to distinguish between them. Professor Owen, in his "British Fossil Mammals," has remarked upon this difficulty, and has pointed out the chief distinguishing characters which may be relied upon for identification, and which lie chiefly in the skull.

So far as we have been enabled to collect the evidence, it would appear that undoubted remains of the wolf have been found in the following localities, for a knowledge of many of which we are indebted to Professor Boyd Dawkins' able paper, "On the Distribution of the British Post-Glacial Mammals," published in the *Quarterly Journal* of the Geological Society.*

Berkshire.—Windsor (Mus. Geol. Survey).

Derbyshire.—Pleasby Vale (Mus. Geol. Survey); Windy Knoll, Castleton (Dawkins, "Quart. Journ. Geol. Soc." xxxi. p. 246, and xxxiii. p. 727); Creswell Crag Caves (Mello and Busk, "Quart. Journ. Geol. Soc." xxxi. p. 684); Dawkins, *op. cit.* xxxii. p. 248, and xxxiii. pp. 590 and 602.

* *See* Vol. xxv. 1869, p. 192.

DEVONSHIRE.—Bench Cave, Brixham (W. A. Sanford); Kent's Hole, Torquay (Mus. Geol. Soc., Mus. Roy. Coll. Surg., and Mus. Oxford); Oreston, near Plymouth (Brit. Mus. and Mus. Geol. Soc.; Owen, "Brit. Foss. Mamm." p. 125).

GLAMORGANSHIRE.—Gower, Bacon's Hole (Mus. Swansea; Falconer, "Palæont. Mem." ii. pp. 183, 325, 340, 349, 501); Bosco's Hole (Mus. Swansea; Falconer, tom. cit. pp. 510, 589); Crow Hole (Mus. Swansea; Falconer, tom. cit. p. 519); Deborah Den (Mus. Swansea; Falconer, tom. cit. p. 467); Long Hole (Falconer, tom. cit. pp. 400, 525, 538); Minchin Hole (Brit. Mus.; Mus. Swansea); Paviland (Mus. Oxford and Swansea; Owen, "Brit. Foss. Mamm." p. 124); Ravenscliff (Falconer, tom. cit. p. 519); Spritsail Tor ("Id." pp. 179, 462, 477, 522).

GLOUCESTERSHIRE.—Tewkesbury (Owen, "Brit. Foss. Mamm.").

KENT.—Murston, Sittingbourne (Mus. Geol. Survey).

NORFOLK.—Denver Sluice* (Mus. Geol. Cambr.).

OXFORDSHIRE.—Thame (Coll. Codrington, "Quart. Journ. Geol. Soc." xx. p. 374).

SOMERSETSHIRE.—Benwell Cave (W. Borrer); Blendon (Mus. Taunton); Hutton (Mus. Taunton); Sandford Hill (Mus. Taunton); Uphill (Mus. Bath and Taunton); Wokey Hole (Mus. Oxford, Taunton, and Bristol).

SUSSEX.—Bracklesham (Brit. Mus. and Mus. Chichester); Pevensey† ("Sussex Archæol." Coll. xxiv. p. 160).

WILTSHIRE.—Vale of Kennet ("Sussex Archæol." tom. cit.).

YORKSHIRE.—Bielbecks (Mus. York; "Phil. Mag." vol. vi. p. 225); Kirkdale (Brit. Mus., Mus. Geol. Soc. and Roy. Coll. Surg.; Buckland, "Trans. Roy. Soc." 1822; Clift, *id.* 1823, p. 90).

We have here a dozen counties in different parts of England and Wales, north, south, east, and west, which show clearly from their position how very generally distributed the wolf must formerly have been.

The geological record, however, is but an imperfect one in showing the distribution of the wolf in bygone times, for to the localities above mentioned might be added numerous others in which we know from history that this animal formerly abounded. The forest of Riddlesdale in Northumberland; the great forests of Blackburnshire and Bowland in Lancashire; Richmond Forest, Yorkshire; Sherwood Forest, Nottinghamshire; Savernake Forest, Wilts; the New Forest; the forests of

* A landscape by R. W. Fraser "On the Ouze near Denver Sluice" was exhibited at the Royal Academy 1877, No. 794. The locality is a few miles to the South of Downham Market, and just below where the old and new Bedford rivers run into the natural stream.

† In 1851 many skulls of wolves were taken out of a disused mediæval well at Pevensey Castle.

Bere and Irwell, and many others are on record as former strongholds of these ferocious animals. To these we shall have occasion to refer later when dealing with the historical evidence.

Unlike other extinct British animals, the wolf apparently has not deteriorated in size, for the fossil bones which have been discovered, as above mentioned, are not larger, nor in any way to be distinguished from those of European wolves of the present day.

Historical Evidence—England.

Ancient British Period.—Dio Nicæus, an ancient author, speaking of the inhabitants of the northern parts of this island, tells us they were a fierce and barbarous people, who tilled no ground, but lived upon the depredations they committed in the southern districts or upon the food they procured by hunting. Strabo also says (lib. iv.) that the dogs bred in Britain were highly esteemed upon the Continent on account of their excellent qualities for hunting, and these qualities, he seems to hint, were natural to them, and not the effect of tutorage by their foreign masters. Hunting the wolf appears to have been a favourite pursuit with these ancient Britons. Mempricius, who is supposed to have reigned B.C. 980, fell a victim in that year to the wolves which he delighted to pursue, and was unfortunately devoured by them. Blaiddyd, another British monarch (B.C. 863), who seems to have been learned in chemistry, is said to have discovered the medicinal properties of the Bath mineral waters, by observing that cattle when attacked and wounded by the wolves went and stood in these waters, and were then healed much sooner than they would have been by any other means.* From this it may be inferred that wolf-hunting was found by the ancient Britons to be a necessary and pleasurable, yet dangerous, pursuit.

We do not find, says Strutt,† that during the establishment of the Romans in Britain, there were any restrictive laws promulgated respecting the killing of game. It appears to have been an established maxim in the early jurisprudence of that people, to invest the right of such things as had no master with those who were the first possessors. Wild beasts, birds, and fishes became the property of those who first could take them. It is

* For this note we are indebted to Mr. John Hoare, who is at present engaged on a most interesting work called "Annals of the Chase in the British Islands," and who has kindly favoured us with a sight of such portions of his MSS. as relate to the wolf.

† "Sports and Pastimes of the People of England."

most probable that the Britons were left at liberty to exercise their ancient privileges; for had any severity been exerted to prevent the destruction of game, such laws would hardly have been passed over without the slightest notice being taken of them by the ancient historians.

Anglo-Saxon Period.—As early as the ninth century, and doubtless long before that, a knowledge of hunting formed an essential part of the education of a young nobleman. Asser, in his life of Alfred the Great, assures us that that monarch before he was twelve years of age "was a most expert and active hunter, and excelled in all the branches of that most noble art, to which he applied with incessant labour and amazing success." Hunting the wolf, the wild boar, the fox, and the deer, were the favourite pastimes of the nobility of that day, and the dogs which they employed for these various branches of the sport, were held by them in the highest estimation.

Such ravages did the wolves commit during winter, particularly in January when the cold was severest, that the Saxons distinguished that month by the name of "wolf month."

"The month which we now call January," says Verstegan, "they called 'Wolf monat,' to wit 'Wolf moneth,' because people are wont always in that month to be in more danger to be devoured of wolves than in any season else of the year; for that, through the extremity of cold and snow, these ravenous creatures could not find of other beasts sufficient to feed upon."*

The Saxons also called an outlaw "wolfs-head,"† as being out of the protection of the law, proscribed, and as liable to be killed as that destructive beast. "*Et tunc gerunt caput lupinum, ita quod sine judiciali inquisitione rite pereant.*"‡

It is to the terror which the wolf inspired among our forefathers that we are to ascribe the fact of kings and rulers, in a barbarous age, feeling proud of bearing the name of this animal as an attribute of courage and ferocity. Brute power was then considered the highest distinction of man, and the sentiment was not mitigated by those refinements of modern life which conceal but do not destroy it. We thus find, amongst our Anglo-Saxon kings and great men, such names as Ethelwulf, 'the noble wolf;" Berthwulf, "the illustrious wolf;" Eadwulf, "'the prosperous wolf;" Ealdwulf, "the old wolf."§

* "Restitution of Decayed Intelligence," p. 64 (ed. 1673).

† Ang. Sax. *Wulvesheofod*, that is, having the head of a wolf. The term was in use temp. Henry II.

‡ Bracton, "De legibus et consuetudinibus Angliæ," lib. iii. tr. ii. c. 11 (1569). *See* also Knighton, "De Eventibus Angliæ," in Twysden's "Historiæ Anglicanæ Scriptores Decem," p. 2356 (1652).

§ Wulfere, King of Mercia (A.D. 660), had a son Wulfade.

In Athelstan's reign, wolves abounded so in Yorkshire that a retreat was built by one Acehorn, at Flixton, near Filey, in that county, wherein travellers might seek refuge if attacked by them.

Camden says:—"More inward stands Flixton, where a hospital was built in the time of Athelstan, for defending travellers from wolves (as it is word for word in the public records) that they should not be devoured by them."* When Athelstan, in 938, obtained a signal victory at Brunanburgh over Constantine, King of Wales, he imposed upon him a yearly tribute of gold, silver and cattle, to which was also added a certain number of "hawks and sharp-scented dogs, fit for the hunting of wild beasts."† His successor, Edgar, remitted the pecuniary payment on condition of receiving annually from Ludwall ‡ (or Idwal §), the successor of Constantine, the skins of three hundred wolves.‖ We do not find, indeed, that the hawks and hounds were included in this new stipulation, but it does not seem reasonable that Edgar, who, like his predecessor, was extremely fond of field sports, should have remitted that part of the tribute.¶

It is generally admitted that Edgar relinquished the fine of gold and silver imposed by his uncle Athelstan upon Constantine, and claimed in its stead the annual production of 300 wolf-skins, because, say the historians, the extensive woodlands and coverts, abounding at that time in Britain, afforded shelter for the wolves, which were exceedingly numerous, and especially in the districts bordering upon Wales. By this prudent expedient, in less than four years, it is said, the whole island was cleared from these ferocious animals, without putting his subjects to the least expense.** But, as Strutt has observed,†† "if this record be taken in its full latitude, and the supposition established, that the wolves were totally exterminated in Britain during the reign of Edgar, more will certainly be admitted than is consistent with the truth, as certain documents clearly prove." The words of William of Malmsbury

* Camden, "Britannia," tit. Yorkshire, vol. ii. p. 902 (2nd ed.).

† William of Malmsbury, "Hist. Reg. Anglorum," lib. ii. c. 6.

‡ *Cf.* Holinshed's "Chronicles," Vol. i. p. 378 (4to. ed. 1807).

§ *Cf.* Camden's "Britannia," tit. Merionethshire, tom. ii. p. 785.

‖ William of Malmsbury, op. cit. lib. ii. c. 8.

¶ Strutt, "Sports and Pastimes of the People of England."

** It is singular that the same expedient has been resorted to in modern times, and with considerable success. In the accounts of Assinniboia, Red River Territory, there is an entry of payment for wolves' heads; and in 1868 the State of Minnesota paid for wolves' scalps 11,300 dollars, at the rate of 10 dollars apiece.

†† "Sports and Pastimes of the English People.'

on the subject are to this effect, that "he, Edgar, imposed a tribute upon the King of Wales, exacting yearly 300 wolves. This tribute continued to be paid for three years, but ceased upon the fourth, because '*nullum se ulterius posse invenire professus*,' 'it was said that he could not find any more.'"*

> "Cambria's proud Kings though with reluctance paid
> Their tributary wolves, head after head,
> In full account, till the woods yield no more,
> And all the ravenous race extinct is lost."

But this must be taken to refer only to Wales, for in the first place it can hardly be supposed that the Welsh chieftain would be permitted to hunt out of his own dominions, and in the next place there is abundant documentary evidence to prove the existence of wolves in England for many centuries later.

Holinshed, who gives a much fuller account, says:†—"The happie and fortunate want of these beasts in England is vniuersallie ascribed to the politike gouernment of King Edgar, who to the intent the whole countrie might once be clensed and clearelie rid of them, charged the conquered Welshmen (who were then pestered with these rauenous creatnres aboue measure) to paie him a yearlie tribute of woolfes skinnes, to be gathered within the land. He appointed them thereto a certaine number of 300, with free libertie for their prince to hunt and pursue them ouer all quarters of the realme; as our chronicles doo report. Some there be which write how Ludwall, prince of Wales, paid yearelie to King Edgar this tribute of 300 woolfes, whose carcases being brought into Lloegres, were buried at Wolfpit, in Cambridgeshire, and that by meanes thereof within the compasse and terme of foure yeares, none of these noisome creatures were left to be heard of within Wales and England. Since this time, also, we read not that anie woolfe hath beene seene here that hath beene bred within the bounds and limits of our countrie: howbeit there haue beene diuerse brought over from beyond the seas for greedinesse of gaine, and to make monie onlie by the gasing and gaping of our people vpon them, who couet oft to see them, being strange beasts in their eies, and sildome knowne (as I haue said) in England."

The learned Dr. Kay‡ acquiesced in the vulgar opinion of

* "Hist. Reg. Anglorum," lib. ii. cap. 8. *See* also Wynne's "Caradoc," p. 51.

† "Chronicles of Engl., Scot., and Irel." (ed. 4to. 1807), Vol. i. p. 378, bk. iii. chap. iv. "Of Savage Beasts and Vermines."

‡ "Joannis Caii Britanni 'de Canibus Britannicis' Liber unus. De rariorum animalium et stirpium Historia." Londini, per Gulielmum

the extinction of wolves in England by King Edgar, and in his work on British Dogs, published in 1570, treating of the sheep-dog (*Pastoralis*), he says: "*Sunt qui scribunt Ludwallum Cambriæ principem pendisse annuatim Edgaro regi* 300 *luporum tributi nomine, atque ita annis quatuor omnem Cambriam, atque adeo omnem Angliam, orbasse lupis.*"

"*Regnavit autem Edgarus circiter annum* 959, *a quo tempore non legimus nativum in Anglia visum lupum.*"

The worthy doctor seems to have been little aware that even at the date at which he wrote wolves still existed in the British Islands. Pennant, referring to the received opinion that a great part of the kingdom was freed from wolves through the exertions of King Edgar, says:—"In England he attempted to effect it by commuting the punishments for certain crimes into the acceptance of a number of wolves' tongues from each criminal; in Wales by converting a tax of gold and silver into an annual tribute of 300 wolves' heads. Notwithstanding his endeavours, however, and the assertions of some authors to the contrary, his scheme proved abortive."*

We have lately met with a statement to the effect that "two wooden wolves' heads still remain near Glastonbury on an ancient house where [query, on the site of which] at Eadgerly, King Eadger lived and received annually his tax from the Welsh in 300 heads."†

This statement, however, conflicts somewhat with that of Holinshed, who says that "the carcases being brought into Lloegres, were buried at Wolfpit in Cambridgeshire."‡

In the Forest Laws of Canute, promulgated in 1016, the wolf is thus expressly mentioned:—"As for foxes and wolves, they are neither reckoned as beasts of the forest or of venery, and therefore whoever kills any of them is out of all danger of forfeiture, or making any recompense or amends for the same. Nevertheless, the killing them within the limits of the forest is a breach of the royal chase, and therefore the offender shall yield a recompense for the same, though it be but easy and gentle."§

It was doubtless to this constitution that the Solicitor-General St. John referred, at the trial of the Earl of Strafford, when he said, "We give law to hares and deer, because they are beasts

Seresium. 8vo. 1570. There is a translation of this work in the British Museum, entitled, "Of Englishe Dogges, newly drawn into English." By Abraham Fleming, Student. London. 4to. 1576.

* "British Zoology," Vol. i. p. 88 (1812).

† "Sussex Archæol. Coll." Vol. iv. p. 83 (1851).

‡ "Chronicles," Vol. i. p. 378 (4to. ed. 1807).

§ *See* Manwood's "Forest Laws." The Charter of the Forest of Canutus the Dane (§ 27).

of chase; but we give no law to wolves and foxes, because they are beasts of prey, but knock them on the head wherever we find them."*

Liulphus, a dean of Whalley in the time of Canute, was celebrated as a wolf-hunter at Rossendale, Lancashire." †

Matthew Paris, in his "Lives of the Abbots of St. Albans," mentions a grant of church lands by Abbot Leofstan (the 12th abbot of that monastery) to Thurnoth and others, in consideration of their keeping the woods between the Chiltern Hundreds and London free from wolves and other wild beasts.

It would seem that the "ancient and accustomed tribute" due to the English kings was repeated by the Welsh princes in the very last years of the Anglo-Saxon monarchy. It was demanded by and rendered to Harold.

* Clarendon, "Hist. Reb." fol. ed. i. p. 183.

† Whitaker's "History of Whalley," p. 222.

(*To be continued.*)

ON THE INTERPRETATION OF SOME EXPERIMENTS RELATING TO THE INDUCTIVE EFFECT PRODUCED BY THE ROTATION OF A MAGNET ON ITS AXIS.

By S. TOLVER PRESTON.

1. A curious and interesting question is raised by some experiments of Faraday, described in the "Philosophical Transactions," in regard to the inductive effect attendant on the rotation of a magnet on its axis. Faraday appears to have considered that experimental results rendered it necessary to draw a distinction between the motion of *rotation* and the motion of *translation* of a magnet, in regard to the behaviour of the system of force about it; for he says ("Phil. Trans." 1852, p. 31), "When lines of force are spoken of as crossing a conducting circuit, it must be considered as effected by the translation of a magnet. No mere rotation of a bar magnet on its axis produces any inductive effect on circuits exterior to it. The system of power about the magnet must not be considered as revolving with the magnet, any more than the rays of light which emanate from the sun are supposed to revolve with the sun. The magnet may even in certain cases be considered as revolving amongst its own forces, and producing a full electric effect sensible at the galvanometer."

2. At the first sight it will appear theoretically a strange conclusion (and Faraday himself designates it afterwards as "singular") that the above distinction between a motion of rotation and a motion of translation should hold. For even if we take the above illustrative case of the sun, it must appear evident (as regards the light emitted from any luminous portion of the sun) that any effect that was produced by the translation of that luminous portion through space would equally be produced by the rotation of that same portion about the axis of the sun, for rotation *is* simply *translation in a circle*. So by the rotation of a magnet on its axis, its constituent parts are *translated* in circles. It would therefore seem necessarily to follow theoretically that any law that applied to the translation of a magnet would equally apply to its rotation. It is an observed fact that by the *translation* of a magnet, the inductive effect produced on

external conductors is precisely the same as if these conductors were themselves translated with the same relative velocity past the stationary magnet, or the effect simply depends on *relative* motion. It would therefore seem a necessary inference that the effect by the rotation of a magnet also depended on *relative* motion, or that the inductive effect on any external conductor would be the same whether the conductor were moved past the periphery of the magnet, or the periphery of the magnet were (conversely) moved with the same relative velocity past the conductor (by the rotation of the magnet on its axis).

3. Faraday, however, appears to have considered that experimental results opposed this inference, for he concluded (as stated in the above quotation) that while the rotation of the conductor about the magnet produced an inductive effect on the conductor, the same relative motion of the magnet to the conductor (when the magnet rotates on its axis) produced no inductive effect on the conductor. The experiment on which this conclusion was grounded was as follows ("Phil. Trans." 1832, p. 183):—A circular disk of copper *d* (fig. 1) was rotated on its axis above the pole of a cylindrical bar magnet *m*. A wire *w* (in whose circuit a galvanometer—not shown—was placed) had one end maintained in sliding contact with the edge of the disk, and the other with the centre of the disk. It was found that the current given off by the rotation of the disk, and passing through the wire *w*, was precisely the same whether the magnet *in addition* was rotated on its axis in either direction, or remained stationary. Hence it was concluded that the rotation of the magnet on its axis produced no inductive effect on the disk, or (generally) that a rotating magnet could produce "no inductive effect on conductors exterior to it." Faraday adds, after a second perfectly similar experiment to the above with a cylindrical copper cap instead of a disk (p. 184)—"Thus a singular independence of the magnetism and the bar in which it resides is rendered evident." In other words, it was inferred that the system of force about the magnet could not be regarded as partaking of the motion of the magnet and crossing external conductors, when the magnet rotated on its axis. It will be observed that this necessarily involves the conclusion that, although the system of force emanating from the periphery of a magnet *admittedly* shares the motion (so as to cross external conductors) when the periphery is moved in the act of *translation* of the magnet, yet that it does not do so when the periphery is moved in the act of rotation of the magnet on its axis. It is difficult to see how this conclusion could be theoretically consistent, for what distinction can be logically drawn between a motion of rotation and one of translation in this case, as by the rotation of a mag-

Fig. 1.

net on its axis its periphery is *translated* in a curve, and evidently a different law could not apply to the behaviour of the system of force according as to whether it is translated in a curved or in a straight line. We should have considerable diffidence in criticizing anything put forward by so eminent an authority, but scientific truth is admittedly paramount, and no one would claim immunity from an oversight. We think it may be distinctly shown that the above is an oversight resting upon the rather curious accident that the particular experiment tried admits of a *double* interpretation.

4. Thus if we make no distinction between the behaviour of the system of force whether the magnet is translated or rotated, or assume that the system of force about the magnet is invariably at rest *relatively to the magnet*, then by the rotation of the magnet on its axis the system of force accompanying the magnet will cross *both* the wire *w* and the disk *d*, thereby tending to generate a current in them both in opposite directions—so that there will be no actual current at all. This is therefore why the magnet when rotated in either direction produces no difference in the results. The final result is the same, not because the rotating magnet produces no inductive effect, but because the inductive effects upon the wire and disk *oppose* each other; or the rotating magnet causes an electric disturbance both in the disk and in the external wire in such a way as to produce a balanced static charge, so that no current is possible. To prove that the inductive effects in the disk and wire exactly balance each other, it is only necessary to rotate the disk and wire together through the lines of force of the stationary magnet, when there will be (as is known) no current in the circuit made up of the disk and wire, the effects in the disk and wire therefore exactly opposing each other. So therefore it becomes clear how the rotation of the magnet on its axis can make no difference in the results; and therefore the experimental result does not warrant the above singular distinction drawn in regard to the behaviour of the system of force when a magnet rotates on its axis. This distinction would indeed involve the conclusion that there is no inductive effect on the disk when the magnet rotates below the disk, but that there is an inductive effect when the disk rotates above the magnet, *i.e.* that the effect is different when the *relative* motion of the disk and magnet is the same, or in other words, that the inductive effect would depend on *absolute* and not on *relative* motion. This is negatived by the behaviour of the helix, whose inductive influence depends (as is known) on *relative* motion; and the same with electrodynamic phenomena generally. It would therefore be strange that the magnet when rotated on its axis should form an exception to the general law, and we think that after it has been shown that the

above experiment admits of just interpretation consistent with the fact that the inductive effect depends on *relative* motion, no one will doubt that this is really the case. However, the point may be independently proved from other considerations.

I. In experiments bearing on this question ("Phil.Trans." 1852, p. 30), a compound magnet was used, consisting of two rectangular bar magnets placed side by side with a slight interval between them (as shown in cross section, fig. 2). The two magnets were rotated about a common axis x. Now if we take a purely theoretic view of this question, and suppose one bar to be removed, then it will be evident that by the rotation of the other about the axis x (now external), the centre of gravity of the bar will be *translated* about that axis, in which case it is *admitted* that the lines of force partake of the motion of the bar and would intersect any external conductor, producing an inductive effect on it. Let now the other magnet be added, and the same holds true of it, *i.e.* its lines of force partake of its motion and intersect any external conductor; and we therefore have now the entire compound bar rotating on its axis, and its lines of force partaking of its motion and intersecting external conductors. This must be sufficiently clear, and if we discuss the matter further, it is with the view rather to consider some facts possessing a certain novelty in their aspects than to add proof to the above conclusion.

Fig. 2.

II. Let us suppose one of the above magnets (fig. 2) to be again removed, and the remaining one to be made to revolve about the external axis x, a copper disk being placed concentrically above this axis. Then by the excentric rotation of the magnet about the external axis x, the centre of gravity of the magnet is *translated* past the disk, so that the lines of force of the magnet intersect the disk and generate currents in it, which discharge themselves in the portion of the disk remote from the pole of the magnet. But if the second magnet be now added, the disk will then (by the rotation of the compound magnet) be continuously and symmetrically covered by the pole of the compound magnet, so that the currents have nowhere to discharge themselves. There is therefore no effect of a current in the disk observed. This is, however, no proof of absence of inductive effect on the part of the rotating magnet; but from the very fact that the currents tend to be generated equally along all the radii of the disk, no back flow is possible, but the centre and circumference of the disk are simply charged up with electricity of opposite sign. If a wire be made to connect the centre and circumference of the disk, the accumulated electricity cannot discharge itself through the wire, because *the wire itself is acted on* by the rotating magnet in the same way as the disk, and no discharge is possible. The disk in this case is charged in pre-

cisely the same way as it would be if (conversely) *it* rotated and the magnet were at rest, or the effect depends simply on *relative*, not on *absolute* motion.

III. The consideration of action and reaction also proves the same point. If a copper disk be oscillated about its own centre (*i.e.* be made to rotate in alternate directions about its centre) above and parallel to the flat surface of the pole of a magnet, and concentric with the magnet's axis, radial currents will (as is known) be generated in alternate directions in the disk at each alternate oscillation of the disk, *i.e.* the disk will be charged at its centre and circumference alternately positively and negatively. This alternate flow of electricity between the centre and circumference of the disk will tend to damp the oscillations of the disk, or to bring it to rest. Now on the principle that action and reaction are equal and contrary, the action between the magnet and disk must be *mutual*, and therefore the magnet, if freely suspended, would tend to be thrown into oscillation (about its axis) by the oscillations of the disk; or if the magnet were (conversely) itself artificially put in oscillation, the magnet would tend to put the disk in oscillation. But the magnet could not do this unless, by its rotation on its axis, *it produced an inductive effect on the disk.* The principle of action and reaction therefore affords additional confirmation of the fact that the rotating magnet has an inductive effect on the disk.

IV. Let NS (fig. 3) represent a spherical magnet suspended so as to rotate freely inside a metallic ring (a slight interval existing between the ring and the magnet), the axis of rotation of the magnet being *perpendicular* to the magnetic axis NS. Then it is an accepted fact that a current (indicated by the arrows) will flow round the ring by the rotation of the magnet, the direction of the current reversing itself at each semi-revolution. The lines of force of the rotating magnet therefore intersect the ring, precisely as they would do if (conversely) the magnet were at rest and the ring rotated through the lines of force of the magnet. If now the magnet be rotated about its *magnetic axis* NS (fig. 4), currents will also be generated, charging up the ring statically in the manner indicated in the figure, the sign of the electricity being opposite at the polar and equatorial parts of the ring (the charge being permanent so long as the magnet rotates). If the existence of this inductive effect be not admitted, then it would be necessary to conclude that the lines of force emanating from the magnet, intersect the ring when the magnet is rotated about one axis (fig. 3), but not so when the magnet

Fig. 3.

Fig. 4.

is rotated about another axis (fig. 4); *i.e.* that the system of force about the magnet obeys one law when the magnet is rotated about one axis, but a different law when it is rotated about an axis perpendicular to the former; which is evidently quite untenable. Indeed it must be perfectly clear that we have here simply a case of *relative* motion, or the inductive effect is the same as if (conversely) the ring were made to rotate about the fixed magnet, when, as a *known fact*, the ring would be charged up in the manner indicated. To assume that a magnet when rotating on its axis produces no inductive effect, would be to assume that when the magnet rotates inside the ring, there is no effect on the ring, but when (conversely) the ring rotates about the magnet, there is an effect on the ring, *i.e.* that the result is *different* while the *relative* motion is the *same*, or that the result depends on the *absolute* motion of the ring. Now it is an admitted characteristic of electro-dynamic phenomena to depend on *relative* and not on *absolute* motion. Moreover, to suppose that it made no difference whether the magnet was rotated or not, would involve the assumption that when magnet and ring rotate *together* with the same velocity, and therefore there is relative *rest*, the effect is the same as when the ring only rotates, or there is relative *motion*. These are therefore some of the inconsistent conclusions to which the above hypothesis necessarily leads, and which thereby prove the hypothesis to be untenable.

V. From the hypothesis that the system of force of a rotating magnet does not partake of the motion of the magnet, it followed as a necessary conclusion that when a magnet rotated on its axis, it revolved through *its own system of force*, producing an inductive effect on itself, charging itself statically at the polar and equatorial parts with electricity of opposite sign. Thus the earth being a magnet, it was considered that the polar and equatorial parts of the earth must be charged up with electricity of opposite sign, by its rotation on its axis, and the surmise was thrown out (merely as a dependent suggestion) that the electric phenomenon of the Aurora Borealis might have some connection with this ("Phil. Trans." 1832, p. 177). The same conclusion was also arrived at by M. Plücker and published in "Poggendorff's Annalen" (1852, p. 357) in a paper—"Ueber die Reciprocität der elektromagnetischen und magnetoelektrischen Erscheinungen." M. Plücker describes a number of experiments with currents in support of his view that a magnet charges itself up by its own rotation; but since all his experiments in *principle* resemble the first one described (with the rotating disk), and since he has overlooked precisely the same fact as that pointed out (the same oversight affecting all his experiments alike), it will be unnecessary to refer to these experiments here.

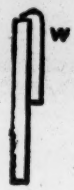
Since we have shown that no distinction can logically be drawn between a motion of rotation and one of translation in regard to the behaviour of the lines of force about a magnet, but that the lines of force must be regarded as accompanying the magnet *whatever* the nature of its motion (*i.e.* the system of force must be regarded as at rest *relatively to the magnet*), so therefore no static charge can ensue by the rotation of the earth on its axis; the system of force about the earth being *relatively to it at rest.* There may be one point that may be worth noticing here. The tides form two elevated protuberances of water which do *not* partake of the earth's rotation, and therefore virtually rotate through the lines of force of the earth. For our purpose the tide may be regarded simply as a stationary ring or belt of water, within which the earth rotates. The inductive effect being dependent on *relative* motion (not on *absolute* motion), the same inductive effect is therefore produced upon the belt of water as if the earth were at rest and the belt of water revolved with the same relative velocity round the earth. It follows therefore that this belt of water will be inductively influenced in such a way that the parts of it lying near the equator are charged up with electricity of opposite sign to the parts lying near the poles. This may therefore constitute a true cause for a disturbance of the electric equilibrium, and which would not exist if it were not for the tides.

VI. As a final illustration of the truth of the point contended for, it may be observed that it is an accepted fact that the magnet and the helix are perfectly analogous in their fundamental properties. Now it is well known that the inductive influence of currents upon each other depends on *relative*, not on *absolute* motion. So then when a helix (or simply a single circular current) rotates on its axis, the rotating helix produces (admittedly) upon external conductors an inductive effect, precisely the same as would be produced if the helix were at rest and the conductors were (conversely) made to revolve with the same relative velocity about the helix, or it is only a question of *relative* motion. So therefore (by analogy), when a magnet rotates on its axis, it produces the same inductive effect on external conductors, as if these conductors were themselves caused (conversely) to revolve with the same relative velocity about the stationary magnet, or it is here also only a question of *relative* motion.

5. This method of viewing the case serves to simplify the phenomena of Electro-magnetic Rotation by correlating them under *one* cause, instead of regarding the mode of action as different in the two cases, first, when the magnet *rotates on its axis*, and, second, when, conversely, the portion of the circuit rotates about the magnet. Thus to take the example

fig. 5, which represents in its simplest form the well-known apparatus for generating an electric current from the relative motion of a magnet and a portion of a circuit; or (conversely) for developing a movement of rotation by means of a current introduced into the circuit. It consists simply of a magnet and a wire, w, the wire being so arranged as to be capable of rotating about the magnet, with its ends maintained (by convenient means) in slipping contact with the polar and equatorial parts of the magnet. By this arrangement of the wire, whatever its shape or length, it cuts (as is known) by one revolution all the lines of force of the magnet. Here a current may be generated either by rotating the wire about the magnet, or by rotating the magnet on its axis, in both which cases the *relative motion of the wire and magnet is the same*, and therefore the cause of the current the same. It was here supposed, however, in accordance with the hypothesis adopted, that the cause of the current was *different* in the two cases. When the wire rotated about the magnet, it was admitted that the current was due to the intersection of the external lines of force of the magnet by the wire. When, however, the magnet rotated on its axis, the current was supposed to be due to a different cause. It was here supposed (according to the hypothesis adopted) that the rotating magnet intersected its own system of force, becoming charged up statically at the polar and equatorial parts, and that the wire, w, led off this charge—that *this*, therefore, was the cause of the current in the wire w. This, therefore, it may be observed, makes a difference in the mode of action in two cases where the *relative* motion is the same. This, however, need not be done, for regarding the system of force about the magnet as accompanying the magnet *whatever* the nature of its motion (*i.e.* the system of force as invariably at rest *relatively to the magnet*), it follows that when the magnet rotates on its axis, its system of force accompanies it and intersects the wire w, thereby generating a current in the wire, precisely as it did when (conversely) the wire, w, was made to intersect the system of force (by the rotation of the wire about the magnet). Thus the effects in both cases become correlated under *one* cause, viz., the *relative* motion of the wire w, and the system of force of the magnet. The singular distinction drawn when the magnet rotates on its axis is therefore shown not to be necessitated by the experimental facts.

Fig. 5.



6. Taking now the reverse case, when the current of a battery is applied either to cause the external wire, w, to rotate about the magnet, or to make the magnet rotate on its axis, the battery current being made to traverse the circuit made up of the magnet and external wire, w. Here, also, evidently the same con-

siderations must apply, or there is no necessity to draw a distinction in the mode of action in the two cases when the magnet rotates (on its axis), and when the wire rotates about the magnet, but the effect is simply one of relative motion. When a current is transmitted through the circuit; the wire, w, reacts upon the system of force of the magnet, and both the magnet and the wire thereby tend to be propelled in opposite directions (or the action is *mutual*). Whether therefore the magnet rotates (on its axis) or the wire rotates about the magnet, merely depends on which is free to move, and therefore the rotation is due to the *same* cause in both cases, *i.e.* to the *mutual* reaction between the wire, w (traversed by a current), and the external lines of force of the magnet. On the other hand, the hypothesis that a rotating magnet and its system of force were *independent* of each other, necessarily would involve the assumption that there can be no reaction between the external wire and the magnet, which leaves us the only remaining conclusion that the magnet is caused to rotate *by the portion of the current within itself*. Here we encounter the difficulty of a current within a body causing the rotation of that body without any external object for the current to react upon. This difficulty disappears at once on the view (already enunciated) that the rotation of the magnet on its axis is due to the reaction between it and the *external* wire, or to the same cause as the rotation of the wire (conversely) about the magnet. This view also brings the properties of the magnet into agreement with those of the helix (as in accordance with Ampère's theory); for it is well known that the rotation of a helix on its axis is solely due to the reaction of the *external* portion of the circuit upon the helix.

7. In connection with this subject, the following experiment was made ("Phil. Trans." 1852, p. 33). A magnet had a portion of wire rigidly attached to it in the form of a loop (as in fig. 5), and magnet and wire were rotated together, when no current was found to exist in the circuit made up of the magnet and wire. This result was accounted for as follows, on the same hypothesis. When the magnet and attached wire rotated together as a whole, the magnet was supposed to rotate through its own system of force, thereby becoming charged up statically; the wire was supposed to rotate through the external system of force of the magnet (the wire also becoming charged up statically), the magnet and the wire thus tending to generate a current in opposite directions, so that this was assumed to be the cause why no actual current was produced. The observed result may however be simply explained on the consideration that, when the magnet and wire are rotated *together*, and rigidly attached, the two are *relatively* at rest, and therefore no induc-

tive effect is produced; not therefore that two disturbances of the electric equilibrium exist in the wire and magnet, and oppose each other, but that no inductive effect at all is produced (there being no relative motion). In this respect also the magnet and the helix agree. For it is well known in the case of a helix traversed by a current, if a conductor of any shape be rigidly fastened to the helix and rotated with it, no inductive effect whatever will be produced, simply because the two are relatively at rest. It may be observed that it is here the case of one and the same hypothesis affecting all the results we have considered, for as soon as it was believed that the experimental results necessitated the above hypothesis, it necessarily (to be consistent) influenced the theoretic deductions throughout. The hypothesis arose, as is sufficiently evident, from a simple oversight, or from not observing the rather curious fact that the experiment, on which it was based, admitted of a *double* interpretation.

8. To summarize the conclusions therefore:—

I. When a magnet rotates on its axis, it produces an inductive effect on bodies external to it. This inductive effect is the same as if the external bodies were themselves (conversely) caused to revolve with the same relative velocity about the fixed magnet. The action of the helix agrees with that of the magnet in this respect (*i.e.* in the effect being dependent on *relative* motion).

II. A rotating magnet does *not* produce an inductive effect on *itself*, *i.e.* does not become statically charged. The system of force about the magnet must be considered as at rest *relatively to the magnet*, and this holds true *whatever* the nature of the motion of the magnet (whether rotatory or translatory). The system of force about the earth (as a rotating magnet) must therefore be considered as at rest *relatively to the earth*, so that the earth cannot become statically charged at the poles by its rotation. On the other hand in the case of the tides, when there is relative motion (in regard to the earth), an electric disturbance may thus be brought about.

III. The inductive effect produced by the movements of magnets and external conductors depends solely on *relative* and not on *absolute* motion, and this holds true independently of the *nature* of the motion of the magnet (whether rotatory or translatory). In this the helix agrees with the magnet, inasmuch as the inductive effect produced by a helix depends on the relative motion of it to external conductors, and no exception has to be made to this, whether the motion of the helix be rotatory or translatory.

IV. So then, when a magnet and an external conductor *rigidly* attached to it are rotated together with whatever

absolute velocity, there is no inductive effect, because the two are *relatively* at rest. It follows therefore that in such a case the two are not charged up statically by the rotation in such a way as to tend to produce currents in opposite directions, but no effect at all is produced.

V. In the apparatus for producing Electromagnetic Rotation, the effect depends merely on the *relative* motion of the magnet and the external portion of the circuit, and the case when the magnet rotates on its axis makes no exception to this law. When the magnet rotates on its axis, or when (conversely) the external portion of the circuit rotates about the magnet, the mode in which the effect is brought about is the *same*, and is dependent on *relative* motion.

9. All the conclusions above summarized apply admittedly to the helix, and therefore to demonstrate them to apply to the magnet is only to reconcile completely two cases where the fundamental properties have been generally considered as identical; but which however could not be reconciled with each other, unless the above supposed distinction when a magnet rotates on its axis could be explained away.

10. Of course on the adoption of Ampère's theory of magnetism, all the conclusions above summarized necessarily apply to the magnet, since this theory was propounded on a recognition of the identity of the properties of the magnet and helix, founded upon observation. Faraday, who apparently considered that experiment compelled the adoption of the above exceptional hypothesis in the case where a magnet rotates on its axis, and which he himself designates as "singular" (opposing as it does the generalization of the properties of the magnet with those of the helix)—would no doubt have been ready to abandon the hypothesis, had he observed that such a course would be consistent with a just interpretation of the experimental results.

REVIEWS.

BRITISH BARROWS.*

THIS excellent work contains a full account of the examination of more than two hundred and thirty sepulchral mounds, belonging to some period before the occupation of Britain by the Romans. The barrows, examined by Canon Greenwell himself, were principally (123) on the Wolds of the East Riding of Yorkshire; but some were in the North (37) and West (2) Ridings, two in Cumberland, several in Westmoreland (19) and Northumberland (31); one in Durham, and five in Gloucestershire. In preliminary observations on each district in which these mortuary mounds occur, the author has given some account of the natural characters of the soil, and of discoveries made by other explorers. An elaborate table, occupying pages 458-478, shows the localities of these barrows, the nature of the interments in them, whether primary or secondary, placed in a grave or not, and burnt or unburnt; also the position of body, and the nature and material of the weapons, implements, vessels, pins, buttons, and ornaments, deposited with the interments.

The description of fourteen *Long Barrows*, opened by the author in Yorkshire, Westmoreland, and Gloucestershire, follows; with special treatment of the characters and probable history of these peculiar sepulchres.

Based on the varied and accurate knowledge of details obtained in this careful opening of tumuli, and enlarged by extensive reading, and by friendly intimacy with antiquaries at home and abroad, an Introduction, comprising what is known about these and other mounds, precedes the descriptive record of the excavations. Of the many interesting subjects treated of in this résumé of what is known of the old Flint-folk and Bronze-people of Yorkshire, the following are first discussed:—the form and material of the barrows, the stone circles enclosing them, the circular holes in their floors, the flint flakes and potsherds so abundantly mixed with their heaps,—the manner of burial of the corpse on the ground, in hollows, or in cists,—of burnt bodies in urns or otherwise,—successive burials in the same barrow,—

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* "British Barrows: A Record of the Examination of Sepulchral Mounds in various parts of England, by William Greenwell, M.A., F.S.A. Together with descriptions and figures of skulls, general remarks on Prehistoric Crania, and an appendix, by George Rolleston, M.D., F.R.S." 8vo. "Clarendon Press," Oxford, 1877. With numerous wood engravings.

the position of the body (usually on the side and contracted with knees and hands near the chin), and the direction of the head.

The occurrence of charcoal in graves with apparently unburnt bodies is accounted for by the supposition that the idea of the necessity of burning, as a rite, or the passing the body through fire, the Purifier, survived the practice of actual and perfect cremation, just as *aspersion* takes the place of complete *immersion* in some forms of baptism.

Traces of personal dress in the burials are rare, but sufficient to render it probable that the body was interred in its clothes or in some kind of shroud. Remains of woollen and leathern garments have been met with; but more frequently there are dress-fasteners, such as bone-pins, buttons of jet, stone, and bone, also jet and bone rings or loops, round or oval, to hold bands or belts together, besides the pins, brooches, and armlets of bronze in the barrows of later date.

Carefully prepared flint weapons and tools, and highly polished stone axes are well known to the mound-diggers. Indeed, our author states that "The barrows are found to contain examples of almost all the stone implements which occur elsewhere." On the contrary, bronze implements are represented by few forms (the plain axe, dagger, knife, drill, knife-dagger, and awl) in the barrows; the spear-heads, swords, flanged axes (paal-stabs), socketed celts, gouges, and chisels, turned up in hoards, not having been found with these burials. The plain axe of bronze, simply moulded after the form of the stone axe, seems to have been the earliest type, from which later modifications arose; and these mound-buried people were of too early a date to know any other.

Their personal ornaments were not very elaborate, nor were they made of gold, glass, ivory, or amber, so far as these researches show. They do not appear to have had any wealth, nor hides or grain to spare for exchange; and possibly they got their bronze and jet by plundering their neighbours. The "pottery of the barrows," carefully studied and richly illustrated, is regarded as having been prepared for the sepulchre alone;* the domestic vessels, well known on sites of habitations, being of a different manufacture, harder and more useful, and destitute of ornament. With all these matters are nearly concerned the social condition of the people (beyond the mere *hunting* state, and with gradations of society), their domesticated animals (few, and not clearly indicated: possibly ox, goat, sheep, horse, and pig), their progress in manufactures and art, and their belief in a future life; and these interesting points are lucidly handled in this Introduction. The entrenchments on the Wolds probably mark the living-places of this long-past

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* As these vessels were *spiritual*, and known to be practically useless, it is quite possible that the *flakes*, *potsherds*, and sometimes *pebbles*, so freely mixed with the earth of mounds, and thrown into graves of much later date (pages 11 and 12), may have been (certainly in earliest times) still more significant of the appliances of every-day life for the deceased. They would directly represent his weapons and tools, his strike-a-light and boiling-stones, and his means for dipping water and carrying hot embers. Poor indeed was the greatest of the heroes, on his dreary death-path, who had not "a sherd to take fire from the hearth, or to take water withal out of the pit." (*Isaiah* xxx. 14.)

people, some of whom were of the *long-head* (dolicho-cephalic) type, most of them, however, being *short-headed* (brachy-cephalic). The latter, who seem to have conquered the former, mixing to some extent with them, were closely related to the Danish stock. In turn they were overpowered by another (Anglian) long-headed race, in the 5th and 6th century after Christ, who brought in iron and silver, and whose descendants still constitute much of the population of the Wolds.

The long barrows belonged to the dolichocephalic oldest population; and the succeeding and dominating race buried their dead in the numerous *round* tumuli which form the chief subject-matter of this comprehensive, learned, and most interesting book. These later burial-mounds of the stronger *round-heads* were raised whilst bronze was still a scarce article, some of them perhaps about or soon after 1000 B.C.; and none of them can well be of later date than 500 B.C., as is well argued at page 131.

Professor Rolleston's description of the skulls, and general remarks on these pre-historic crania, is in itself a most valuable work to anthropologist, historian, and general reader. It comprises a practical treatise on craniography, a detailed account of the calvariæ submitted for his examination, an elaborate essay on pre-historic crania, and almost exhaustive treatises on the trees of pre-historic Britain, and the animals, such as the bee, fowl, deer, rabbit, dog, pig, sheep, ox, and others, associated, or supposed to have been associated, with pre-historic man. The amount of personal experience, of information communicated by friends, and of scholarly research into ancient facts and opinions, shown in these papers, is most striking, and will be fully appreciated by all readers, whether of general or scientific tastes. It not only proves, also, the great worth of the Linacre Professor of the Oxford University, his special industry and acumen, but supplies a noble supplement to Canon Greenwell's excellent "Record of British Barrows"—which is indeed an Essay towards the history of forgotten races, who have not only left their mark on English soil, but doubtless played their part in making up the composite character and constitution of Englishmen themselves.

THE ORIGIN OF THE WORLD.

WE know from the words of that illustrious philosopher, Mr. Ephraim Jenkinson, as recorded by the learned Dr. Primrose, that "The cosmogony, or creation of the world, has puzzled philosophers of all ages," and he adds, "Sanchoniathon, Manetho, Berosus, and Ocellus Lucanus have all attempted it in vain." In such distinguished company Principal Dawson need hardly be ashamed to take his place. At any rate the difficulties of the question are not removed by the publication of his book on the Origin of the World; and we fear that in what is really the main purpose of the book, namely, the reconciliation of the statements as to the creation of the world contained in the book of Genesis and the results of modern science, our author has not been much more successful than his predecessors. As by most, if not all, of the latter; the creative "days" of the Bible narrative are expanded by Principal Dawson into periods of unknown length, and the

table of creative periods given by him (p. 353) will perhaps show better than a long discussion what are the precise views he holds. It is as follows:—

PARALLELISM OF THE SCRIPTURAL COSMOGONY WITH THE ASTRONOMICAL AND GEOLOGICAL HISTORY OF THE EARTH.

Biblical Æons	Periods deduced from Scientific considerations
The Beginning.	Creation of Matter.
First Day.—Earth mantled by the vaporous deep — Production of light.	Condensation of Planetary bodies from a nebulous mass—Hypothesis of original incandescence.
Second Day.—Earth covered by the waters—Formation of the atmosphere.	Primitive universal ocean, and establishment of atmospheric equilibrium.
Third Day.—Emergence of dry land —Introduction of vegetation.	Elevation of the land which furnished the materials of the oldest rocks—Eozoic period of geology.
Fourth Day.—Completion of the arrangements of the solar system.	Metamorphism of Eozoic rocks and disturbances preceding the Cambrian epoch — Present arrangement of seasons—Dominion of "Existing Causes" begins.
Fifth Day.—Invertebrates and fishes, and afterwards great reptiles and birds created.	Palæozoic period—Reign of invertebrates and fishes.
	Mesozoic period—Reign of reptiles.
Sixth Day.—Introduction of mammals—Creation of man and Edenic group of animals.	Tertiary period—Reign of Mammals.
	Post-tertiary — Existing mammals and man.

The seventh and eighth days we may omit.

One has only to read over the simple narrative of the Biblical writer to see that a good deal of non-natural interpretation is necessary to arrive at this view of the meaning of the Genesiac cosmogony, even if we are prepared to accept without cavil the statements of the second column as giving absolutely the results of modern investigation. The Biblical writer says, "In the beginning God created the heavens and the earth," which is evidently a prefatory statement; and he then goes on to describe how the operation of Creation was performed, but he says nothing about the creation of matter, which, we may fairly presume, had he thought about it, would have puzzled him as much as it did Sanchoniathon, Berosus, and the rest of them, including Principal Dawson himself.

It is unnecessary to go further, as the table speaks for itself, and the reader will have little difficulty in recognizing the strained interpretation put upon the Scriptural record, in order to bring it into accordance with the assumed scientific results. It is clearly necessary to admit that some portions, at any rate, of the Bible are only the expression of human thoughts, and the most orthodox of us may safely regard this Genesiac account of the Creation as coming under such a category.

It need hardly be said that Principal Dawson does not accept the modern doctrines of evolution, but at the same time he admits that if we understand evolution as signifying merely the carrying out of the plans of the Creator

in the formation and perfecting of the Universe and its living inhabitants, there is nothing in such a notion that need "in itself be a bugbear on theological grounds." At the same time he considers that, before even the hypothesis of the gradual evolution of organic forms by descent with modification can be accepted, we require to possess a much larger array of facts; and the doctrine of evolution against which he specially protests "is the spontaneous evolution of nothing into atoms and force, and of these into all the wonderful and complicated plan of nature, without any guiding mind."

With regard to the origin and history of the human race, Dr. Dawson seems to have placed himself in a position of unnecessary difficulty by taking the date of the first appearance of man, the scriptural Adam, "not a myth or an ethnic name, but a veritable man," from such chronological data as can be derived from Scripture, and fixing it at from 4000 to 5000 years B.C. In discussing the human question, however, he admits the evidence proving the co-existence of man in Europe successively with the Mammoth and the Reindeer, and explains it after a fashion that will be hardly satisfactory to our readers. The Mammoth-men, according to him, are a portion of the pre-diluvian descendants of Adam, whilst the probably Eskimo-like Reindeer-men are post-diluvian!

While we find it impossible to agree with Principal Dawson either in the general tendency of his work or in many of its details, we must confess that it is a pleasant and readable book enough, and one that will doubtless be welcomed with delight by many who will look at it, rather from the theological than the scientific point of view. For ourselves, holding all spiritual religion to be a matter of faith and not of demonstration, and regarding the prevalent Bibliolatry of Protestant countries as a most mischievous element in modern Christianity, we cannot but regret that the author should have devoted so much of his time to the elaboration of the present work.

BIOLOGY.*

THIS is a volume of "The Library of Contemporaneous Science," which Messrs. Chapman & Hall are publishing, with a view to render good modern science more available to the educated classes. It appears that MM. Reinwald & Co. have made arrangements with certain foreign authors to do the original work, and that Messrs. Chapman & Hall have decided to present it in an "English dress," by means of some of the "best writers and recognised authorities here." It does not appear in the publishers' preface why English authors were not asked to do the original work, but possibly the affectation, as Herbert Spencer has it, which induces some men to depreciate the work of their own nationality, has not been without its influence.

Dr. Letourneau has produced a very good and readable book, far in advance of anything of the kind in this country, and his translator has performed by no means an easy task faithfully and very intelligently. It is a book which may be placed in the hand of an advanced student, of any member of the

* "Biology." By Dr. Charles Letourneau. Translated by William Maccall. 8vo. London. Chapman & Hall. 1878.

medical profession, and of most chemists; and if they will only condescend to study, the great mass of superficial readers will benefit by it. But it is not an easy book, for it deals with great problems; and as it is written conscientiously, it will rather astonish some people who follow blindly whatever the dominant school preaches. Letourneau is a philosophical evolutionist: he believes in spontaneous generation, and discredits all that one reads about germs. As a sensible man, he asserts the positivity of atoms, and thus defines life: "Life is a twofold movement of simultaneous and continual composition and decomposition, in the midst of plasmatic substances, or of figurate anatomical elements, which, under the influence of this indwelling movement, perform their functions in conformity to their structure." If we did not know it before, this sentence would lead us to believe that life is sufficiently mysterious and incapable of formulation. The references to the positive part of Biology are good and up to the day; and the chapters which deal with function and reproduction and persistence are full of good original suggestions and careful quotations. Thus, in treating of the office of respiration, there is the following very suggestive sentence: "Behind every biological activity there is an oxydation of the anatomical elements; no organ escapes this law, and the nervous centres are as much in subjection to it as the other organic apparatus. Every thought, every volition, every sensation, corresponds to an oxydation of the living substance, as well as every secretion, every movement," &c. There is a singular blunder on page 269, in which a Malpighian body of the kidney does duty for one in the bladder. Further on, the Brownian movement is stated to be caused by phenomena of attraction at short distances and belongs to the domain of capillarity!—it has nothing to do, according to the author, with simple liquid currents. Due to the same cause that produces the motion of the vacuoles in the cavities of crystals, minute heat currents are certainly dynamical in this movement, which is so different from that of independent living things. Bathybius crops up, but its hypothetical nature seems hardly to have been understood; and an error of a distinguished British physicist is reproduced in the assertion that Dr. Mayer founded the "great doctrine of the unity of forces." Supposing that by this is meant the doctrine of the mechanical equivalent of heat and the theory of the conservation of energy, there is not the least justification for placing Mayer before Dr. Joule, of Manchester. Joule made the experiment, and proved by theory and practice what Mayer dreamed about and fancied, and never proved by experiment.

Everyone who has translated a French scientific work will sympathize with Mr. Maccall; and we do not wish in any way to detract from the credit due to him, when we suggest that before the book passes to a second edition some scientific man of standing should point out certain old-fashioned expressions, which would be all the better if Anglicized and modernized.

AMERICAN STATE PUBLICATIONS.

ONCE again we have to notice the wonderful series of scientific publications brought out under the auspices of the Government of the United States And we may worthily begin with the records of the labours of the Geologi-

cal Survey of the Territories, conducted with so much spirit by Dr. F. V. Hayden, seeing that the grandest volume that we have to notice, just received, is issued by that department. This, which is the eleventh volume of the Report of the Geological Survey of the Territories,* contains a series of monographs of the families of North American Rodents by MM. Elliott Coues and J. A. Allen, the extreme value of whose work upon the Mammals of North America is so well known as to render any praise or criticism on our part quite superfluous. Our notice of this magnificent volume of more than 1,100 quarto pages must be limited to a general indication of its contents. The classification adopted by the authors divides the order Rodentia into the two well-known sub-orders, Simplicidentati, with two, and Duplicidentati, with four, incisor teeth in the upper jaw, the latter including the Leporidæ, or true Hares, and the Lagomyidæ, Pikas, or Calling Hares, both of which families are treated by Dr. Allen. Of the nine families into which the much larger group of the Simplicidentati is divided, the Muridæ, Zapodidæ, Saccomyidæ, Haplodontidæ, and Geomyidæ are described by Dr. Coues; and the Sciuridæ, Castoridæ, Hystricidæ, and Castoroididæ by Dr. Allen. Of these groups the Zapodidæ constitute a family established for the reception of a single species—the Long-legged Mouse or Jumping Mouse, originally described as a Jerboa, under the name of *Dipus hudsonius*, but which, according to Dr. Coues, exhibits characters distinguishing it quite as much from the true Dipodidæ as from the Muridæ. The family Castoroididæ is a new one, proposed for the reception of the great extinct Rodent, *Castoroides ohioensis*, the remains of which have been obtained from post-tertiary deposits in various parts of North America. This animal, which was about the size of an adult black bear, was long supposed to have been a gigantic beaver. Dr. Allen, however, places it in the Hystricine group. It is the largest known Rodent, except an extinct Capybara (*Hydrochœrus*) described by Lund, from the Brazilian Bone Caves.

Each of the above families is treated monographically, its position in the system being discussed, its genera and species, and the habits of the latter, described, and its bibliography given. Under some of the families, the extinct North American species belonging to them are noticed, and in an appendix Dr. Allen gives a list of the known extinct Rodentia of North America, with short notices of those not referred to in the monographs. A second appendix contains a valuable bibliographical list of works relating to North American Mammals by Dr. T. Gill and Dr. Coues; and the whole concludes with a general alphabetical index to the volume. The illustrations consist chiefly of woodcut figures of the skulls of Muridæ, which are printed on five plates.

The ninth Annual Report of what we in England should regard as the more legitimate doings of the Survey, contains an account of the exploration of Colorado and adjacent territories, surveyed in the year 1875.† The actual

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* Report of the United States Geological Survey of the Territories. F. V. Hayden, U.S. Geologist-in-Charge. Vol. XI. Monographs of North American Rodentia, by Elliott Coues and Joel Asaph Allen. 4to. Washington. 1877.

† Ninth Annual Report of the United States Geological and Geographical Survey of the Territories, embracing Colorado and parts of adjacent Terri-

region examined comprised the southern and south-western portions of Colorado, with a belt, fifteen miles in width, of Northern New Mexico and Eastern Utah. The reports of the geological surveyors, MM. Peale, Endlich, and Holmes, which are illustrated with numerous maps and sections, give a most interesting account of the geology of that curious region, where the forms produced by peculiarities of rock-structure under the influence of denudation are amongst the most singular of geological phenomena. Mr. Endlich especially describes and figures some wonderful groups of earth-pillars, which occur in some localities in great numbers, and of a size compared with which those of Botzen are insignificant; 60–80 feet being the average height, whilst some examples rise to 400 feet. The rock of which these pillars are formed is a volcanic sand re-deposited by the action of water, and containing innumerable trachytic boulders of various sizes, which form the protective cappings of the pillars. Another extraordinary phenomenon is the formation of very regular arches of large size in narrow vertical walls of the same rock. Mr. Mudge's notes on the Tertiary and Cretaceous periods of Kansas are reprinted with additions at the close of the Geological Report on Colorado. Passing over the second part, which gives an account of the topographical labours of the Survey, the first article in the zoological section is a reprint, with additions, of a most valuable memoir by Dr. J. A. Allen, upon the history of the American Bison. Dr. Allen here furnishes us with an exhaustive treatise upon this interesting but ill-fated animal, whose disappearance from the face of the earth is certainly only a question of time. The story of its destruction, often from pure wantonness, at the hand of man, and its retirement as human inhabitants make their way into the wilderness, is a melancholy one, and is told in great detail by Dr. Allen, who foretells the speedy extermination of this great quadruped, and strongly urges that attempts should be made at its domestication, which does not appear to be a very difficult matter. Dr. A. S. Packard furnishes an excellent summary of the information acquired respecting the natural history of the Rocky Mountain Locust (*Caloptenus spretus*), the ravages of which in certain years are so serious. Dr. Packard believes that, by meteorological observations, the occurrence of "locust years" may be predicted, and preparations made by the farmers to receive their enemies. He also recommends the planting of forests along lines of railroad, and certain other precautions which would no doubt tend greatly to diminish the mischief done by this pest. Dr. Packard's report also refers to the Red-legged Locust (*Acrydium femur rubrum*), another destructive species in some districts, and to some others of more local occurrence; and he further reports on numerous injurious insects of various orders which inhabit the United States. This exceedingly interesting and valuable report is copiously illustrated with woodcuts and with nine plates of figures, and also with several maps, showing the range of some of the more destructive species. It is accompanied by a list of Coleoptera collected by Dr. Packard in California and Utah in 1875.

Another volume, which must take its place side by side with the grand

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tories; being a report of progress of the Exploration for the year 1875. By F. V. Hayden. 8vo. Washington. 1877.

volume on the Rodents of North America, is Dr. Elliott Coues' account of the Fur-bearing Animals of that continent*—a group of mammals whose history may perhaps be considered to appeal more strongly to our general interests than any others, except those directly serving as food for man. The Fur-bearing Animals are restricted in this volume to the family Mustelidæ, of which North America appears to possess nine—the Wolverine, Martens, Weasels, Skunk, Badger, Otter, and Sea Otter. These animals are all described in scientific form, and the descriptions are accompanied by a complete *résumé* of all the particulars relating to the natural history of the animals, which have been accumulated by a long series of observations on the part of the zoologists of the United States upon the species living within their range, and by the, perhaps, somewhat interested remarks of the hunters and trappers, who are, to a considerable extent, dependent on their knowledge of the habits of the animals for the successful prosecution of their trade. In fact, the volume furnishes an admirable monograph of the North American species of the carnivorous family of which it treats. The osteological characters, and especially the cranial peculiarities, which appear to be of special importance, are fully described, and the latter are illustrated by good figures, occupying about 20 plates.

The Ethnography and Philology of the Hidatsa Indians, better known, perhaps, as the Grosventres, constitute the subject of another volume of the miscellaneous publications of Dr. Hayden's Survey.† Mr. Washington Matthews, the author, gives an elaborate account of this tribe of Indians—the remnants of which at present live in the village at Fort Berthold, in Dakota,—which he follows up with a grammar and a dictionary of the principal words of their language. The Ethnographical section commences with an interesting account of the village at Fort Berthold, which is inhabited by members of three distinct tribes of Indians—the Hidatsa, the Mandans, and the Arickarees,—and it is a remarkable fact that, according to Mr. Matthews, these Indians, although living in close juxtaposition, and often intermarrying, still retain their respective languages quite uncorrupted, although they generally possess a knowledge of those of the other tribes; and, in fact, it is not uncommon among them to find persons who can speak four or five languages fluently. The Hidatsa, or Minnetarees, with whom the Crows appear to have been united, were, even in former days, a comparatively cultivated tribe, practising agriculture to a sufficient extent to enable them to dispose of corn to their neighbours; and the general testimony of travellers, which is fully endorsed by our author, is highly in their favour. Mr. Matthews gives an account of their habits, customs, and superstitions, which may interest the general reader as much as the philological treatise will gratify the student of the American Indian languages.

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* "Fur-bearing Animals: A Monograph of North American Mustelidæ," &c. By Elliott Coues, U.S. Geological and Geographical Survey of the Territories, Miscellaneous Publications, No. 8. 8vo. Washington: Government Printing Office. 1877.

† "Ethnography and Philology of the Hidatsa Indians." By Washington Matthews, U.S. Geological and Geographical Survey, Miscel. Publ., No. 7. 8vo. Washington. 1877.

The Descriptive Catalogue of Photographs of North American Indians,* by Mr. W. H. Jackson, contains a good deal of information about the Indian tribes, which will be found interesting, even without the admirable series of photographs to which it is intended as a guide. The last publication of the Survey of the Territories that we have received is a fourth edition of the Lists of Elevations† in the country surveyed by Dr. Hayden and his staff. These lists were first published in 1872, when they formed a 12mo pamphlet of 31 pages; the additional observations since made have brought the work up to 160 closely-printed 8vo pages of tables of elevations, illustrated with a large contour map.

A most valuable volume is the Report of the Commissioner of Fisheries ‡ for the years 1873-5, which contains not only the Commissioner's formal statement of the results of operations carried on under the auspices of the Commission during those years, but also a series of appendices giving the most varied information from all sources upon subjects connected with Fish and Fisheries. From these documents we learn that the system of artificial propagation is being adopted with great energy by the Americans, especially in the case of the Atlantic salmon, the Californian salmon, and the shad; and that the eggs and young fry of these fishes have been transported into new waters with a considerable amount of success. With regard to the shad, the Commission even attempted to send a supply of the newly-hatched fry from America to Germany, with a view to the introduction of the American species into European rivers, in return for a large consignment of young Rhine salmon sent by the German Government to America. The experiment was unsuccessful, but the gentlemen sent in charge of the fish think that it would not be difficult to transport the shad to Europe by placing the eggs in an ingenious hatching apparatus which they have invented, and which is described and figured in the present volume. In the appendices, besides elaborate reports upon the steps taken by the agents of the Commission for carrying out its objects in various parts of the United States, we find translations of important memoirs on food fishes and their propagation, and on fisheries, which have been published during the last few years in different European countries; the most important being those from Danish, Swedish, and Norwegian sources, which may be regarded as peculiarly inaccessible to most English readers. There is also a translation (from the French) of a valuable Russian report on Fisheries and Seal-Hunting in the White Sea, the Arctic Ocean, and the Caspian. The book, in fact, contains an immense mass of information of the highest value to the ichthyologist. There is also a brief report upon the results of dredgings made in 1873 in the Gulf of Maine, and a list of the Marine Algæ of the United States, both arising out of the investigations of the marine

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* "Descriptive Catalogue of Photographs of North American Indians." By W. H. Jackson, Photographer to the Survey. Miscel. Publ., No. 9. 8vo. Washington. 1877.

† "Lists of Elevations, principally in that portion of the United States West of the Mississippi River." By Henry Gannett. Fourth edition. Miscel. Publ., No. 1. 8vo. Washington. 1877.

‡ "United States Commission of Fish and Fisheries. Part III. Report of the Commission for 1873-4 and 1874-5." 8vo. Washington. 1876.

natural history of parts of the coast of the United States, which are undertaken every summer by the officials of the Commission.

In the Report of the Commissioner of Agriculture for 1875* we have a volume which, although not so interesting throughout to the scientific naturalist as that of the Fisheries' Commission, nevertheless contains several important contributions in addition to those of a more purely industrial bearing. The entomologist, Dr. Townend Glover, furnishes an account of the habits of those species of the Heteropterous Rhynchota, or Bugs, which are either injurious or beneficial to man; Mr. George Vasey, the botanist, gives a list of the Forest Trees of the United States, a subject which is further illustrated by a long and elaborate report, with maps, on the statistics of forestry; the microscopist, Mr. T. Taylor, notices the microscopic appearances of cellulose and starch, and contributes a paper on the diseases of fungal origin known as "Cranberry rot and scald"; and Mr. J. R. Dodge has a long paper on the Sheep and Wool of the World.

Of the Smithsonian Report for 1876† we need say little more than that, besides the formal reports of the progress of the Institution, it contains the usual selection of memoirs upon various scientific subjects. Among these, translations of Arago's Eulogy on Gay Lussac, and of a biography of the present Emperor of Brazil, will be read with interest; as also a memoir on "Kinetic Theories of Gravitation," by Mr. W. D. Taylor, in which the author discusses the various speculations that have been put forward on this subject. Several original papers on American Ethnology, illustrated with figures of pottery, articles of stone and wood, and curious earthworks, are also of much interest.

HUXLEY'S INVERTEBRATA.‡

SOME twenty years ago, not long after he succeeded the late Professor Edward Forbes at the School of Mines, Professor Huxley commenced the publication, in the "Medical Times and Gazette," of a series of lectures on Comparative Anatomy, which, to the regret of many students of Zoology, came to an untimely end. Subsequently, in 1871, he brought out his well-known "Manual of the Comparative Anatomy of Vertebrated Animals," which is now succeeded by a corresponding volume on the Invertebrata.

It is hardly necessary to say that this book, which forms a stout little volume of some 700 pages, is a most welcome addition to our stock of Zoological literature. The author's eminence as an original investigator (first established by most valuable researches upon several types of invertebrate animals), his intimate acquaintance with all the modern literature of the subject, his experience as a teacher, and his wonderful power of lucid exposition,—all combine to assure us *à priori* that in his present work we shall have, what

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* "Report of the Commission of Agriculture for the year 1875." 8vo. Washington. Government Printing Office. 1876.

† "Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the year 1876." 8vo. Washington. 1877.

‡ "A Manual of the Anatomy of Invertebrated Animals." By Thomas H. Huxley, LL.D., F.R.S. Sm. 8vo. London: Churchill. 1877.

has long been much wanted,—a thoroughly good and trustworthy English treatise on the morphology of the Invertebrates. And a pretty close inspection of it, whilst revealing one or two points to which we might, perhaps with some ground, demur, shows, nevertheless, that, so far as can be expected from a manual dealing with so vast a field, these anticipations are fulfilled. Throughout the book the structure and development of the animals forming the great natural groups of Invertebrata are admirably described, and many particulars as to their relations to the world outside of them are given.

In carrying out this plan the author has not attempted to give any prominence to the question of classification, his object being, as he says in his preface, to give clear ideas of the morphology of the great natural "orders" (classes of most zoologists), leaving the question of larger natural divisions to some extent on one side; and in this way, while the different well-known groups are brought together under definite sections, certain others, of doubtful affinities, are treated of in a final chapter, together with one or two which have been established since the earlier portion of the work was printed. But this apparent disregard of classification is due to no depreciation of its importance, but rather to Professor Huxley's feeling, that at the present moment the science of zoology is still in a somewhat uncertain state, the old hard and fast lines of system having been considerably broken in upon, whilst no new views have been put forward with sufficient force to take their place. According to the author (and we think this expression of opinion may perhaps have a beneficial influence on the minds of some of our younger zoologists), classification is the "superstructure and outcome" of morphology; or, in other words, the best classification is, as it was always considered by the older zoologists, the best exposition of the sum of our knowledge of the organisms under consideration.

One is the better pleased to find a naturalist like Professor Huxley taking this view of the present state of Zoology, because he is, as his new work sufficiently shows, deeply imbued with the views of development maintained by Häckel; and both that distinguished professor and many of his followers adopt a rather strongly dogmatic tone in expressing their opinions on systematic points. We are all familiar with the beautiful genealogical trees which have lately been so often put forward. Professor Huxley treats us to nothing of the kind; but he speaks of phylogeny as "a special branch of biological investigation;" and adds: "In practice, the reconstruction of the pedigree of a group from the developmental history of its existing members is fraught with difficulties. It is highly probable that the series of developmental stages of the individual organism never presents more than an abbreviated and condensed summary of ancestral conditions, while this summary is often strangely modified by variation and adaptation to conditions; and it must be confessed that, in most cases, we can do little better than guess what is the genuine recapitulation of ancestral forms, and what is the effect of comparatively late adaptation." He hopes that by phylogenetic investigations, founded on the study of ontogenetic development and of fossil organisms combined, "a perfectly safe foundation for the doctrine of Evolution" may be arrived at.

With regard to the fundamentals of the doctrine of Evolution, Professor Huxley is equally candid. He says: "Three views may be taken of the causes of variation:

"*a.* In virtue of its molecular structure, the organism may tend to vary. This variability may either be indefinite, or may be limited to certain directions by intrinsic conditions. In the former case, the result of the struggle for existence would be the survival of the fittest among an indefinite number of varieties; in the latter case it would be the survival of the fittest among a certain set of varieties, the nature and number of which would be predetermined by the molecular structure of the organism.

"*b.* The organism may have no intrinsic tendency to vary, but variation may be brought about by the influence of conditions external to it; and, in this case also, the variability induced may be either indefinite or defined by intrinsic limitation.

"*c.* The two former cases may be combined, and variation may to some extent depend upon intrinsic, and to some extent upon extrinsic, conditions.

"At present it can hardly be said that such evidence as would justify the positive adoption of any one of these views exists."

With this quotation we may take leave of Professor Huxley's book, recommending it to our readers as the most moderate and philosophical exposition of the views of the advanced school of Zoologists that they are likely to meet with for some time. The little volume is very freely illustrated with woodcuts, which, if not first-rate as works of art, generally represent well enough the objects they are intended to show.

ELEMENTS OF CHEMISTRY.*

WHEN the first edition of the Chemical Physics appeared twenty-three years ago, it was pointed out by the late Professor Miller that it was devoted to a subject upon which no elementary work had then appeared in this country since the publication of the excellent treatise of the late Professor Daniell. The interval has seen the production in an English garb, of some translations of text-books in which Physics has been treated from a chemical point of view, but the usefulness of the "Chemical Physics" has not waned. In the fifth edition, issued in 1872, so much additional matter was incorporated that the book was half as large again as the first edition; the present is nearly double its size. The main branches of the subject are, with a few slight modifications, treated in the same order as heretofore. In the chapter on the air-pump a description and woodcut are provided of the Sprengel pump, the complex form of which will startle a beginner; reference is made in this place to the simplest form of the instrument to be found in later pages; it may, however, be missed, as the number attached to the figure is misprinted. It is interesting, in passing, to observe that the best exhaustion obtained by the Sprengel pump was in one instance $\frac{1}{937920000}$ of the atmosphere. Allusion is made to the water barometer placed by Daniell "in the hall of the Royal Society:" we believe that an instrument of this kind, set up

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* "Elements of Chemistry: Theoretical and Practical." By William Allen Miller. Part I. Chemical Physics. Sixth Edition. Revised by Herbert M'Leod. 8vo. London: Longmans. 1877.

a few years since, still forms a feature of the Technological Museum in the Crystal Palace.

In the chapters treating of solution of substances we find for the first time that Mr. M'Leod still retains a form of nomenclature attempted to be introduced some years since, but which never obtained general acceptance; we refer to such expressions as "magnesic and zincic sulphate." "Magnesic" is not nice, but "zincic" is "most intolerable and not to be endured." Further on, when dealing with the separation of bodies by cold, we find references to the observations of Rae, and the recent experiments of Buchanan and Guthrie. It is interesting to trace, under Light, the subject of prismatic analysis, of which so little was said in the first edition, extended to a report, rich in recent results, in the present edition; it is brought down to date by reference to the lines of the new metal gallium. The woodcuts taken from photographic spectra of the elements on pp. 277-8 are sadly blurred in the printing. As the production of cold by vaporization has attracted considerable attention of late, we were led to expect, what we do not find, a description of Carré's newer and very elegant apparatus for the freezing of water, based on Leslie's method, which is however mentioned, and which it so beautifully illustrates. The rapidity with which a pint of water can be frozen by its means renders it a most valuable aid in a chemical or physical laboratory, as well as a means of producing a very striking lecture experiment. Again, we cannot help feeling that the reader will experience some difficulty in grasping the principle of Holtz's electrical machine for want of an illustration. The machine is of increasing practical importance from the fact that it will remain charged for many hours. We regard these as shortcomings, as we have noticed in another part of the work more than one illustration of the same apparatus. Many examples could be quoted in testimony of the aim having been in all the chapters to incorporate all recent scientific results of established importance, and we may content ourselves by alluding, in support of this, to the fact that the declination and inclination of the magnetic needle for the present year (1877), as registered at Kew Observatory, are given, and to a note on the remarkable experiments of De La Rue and Müller with their new form of battery. The meanimg of an expression used in this note, "a condenser of 44.8 microfarad capacity," will puzzle the general reader, while reference to the index will throw little light on the problem.

THE ART OF ELECTRO-METALLURGY.*

THE present volume is, we believe, the most recently published of the valuable series of text-books of science which are being issued by Messrs. Longmans "for the use of artisans and of students in public and science schools." The author has provided a vast amount of information on the subject, and has increased the usefulness of his text-book, so far as some of his readers are concerned, by supplying, page by page, abundant references to original memoirs, thus placing those who consult his book in a position to

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* "The Art of Electro-Metallurgy, including all known Processes of Electro-Deposition." By G. Gore. Sm. 8vo. London: Longmans. 1877.

gather any additional detailed information respecting the various processes to which they may have occasion to refer.

We cannot turn over the pages of the historical sketch which forms the opening chapter of the book, without experiencing a feeling of satisfaction at the manifestly large share taken by our countrymen in the development of this branch of industrial science. Next we have an exposition of the principles and laws of "Electro-Metallurgy" which is for the most part all that could be desired. The atomic weights of elementary substances, as given in this chapter, vary considerably in some cases from those at present accepted. When speaking of the means of measuring a galvanic current, the author states that "the instruments usually employed for that purpose are either a galvanometer or a voltameter," and further, that "what is termed 'a tangent' one may be conveniently employed." The reader will hardly gather from this that the two forms of galvanometer differ very materially as regards their use as *measurers* of currents. What is generally known, is that in the instrument usually termed the galvanometer (or multiplier), the deflections of the needle, while increasing with the intensity of the current, bear no simple relation to it, and the relation has to be determined experimentally for each apparatus; in the case of the tangent compass, however, the tangents of the angles to which the needle is deflected by the currents are proportional to the currents causing the deflections. From the theoretical we pass to the practical division of the book, which occupies about one half of the volume, and is devoted to the processes employed for the electro-deposition of metals and metalloids. Class I. is intituled "Gaseous Metals," and *they* are hydrogen. Although hydrogenium is referred to, and Böttger's modification of an earlier experiment is described, the name of Graham is conspicuous by its absence; the author directs attention to his own researches on the electrolysis of hydrofluoric acid and hydrochloric acid. He speaks in this chapter of water as a "salt" of hydrogen (p. 94); then we find "arsenic acid" is a "salt" (p. 97), black oxide of manganese is a "salt" (p. 250), and caustic lime is a "salt" (p. 292). What, we ask in despair, is *not* a "salt"? Mr. Gore appears to have lost sight of the chief aim of the series of text-books of which his forms one; they are intended to serve for the use of practical men, and as regards style and subject-matter to be within the comprehension of working men, and suited to their wants. Our chemical nomenclature is unhappily difficult and bewildering enough as it is, and every effort should be made to simplify it and render it comprehensible to every reader. Will those who use his book know that by "chloride of ammonia," "chloride of ammonium" and "sal ammoniac" three names used within a few pages of each other, it is intended to indicate the same substance? Again, on one page we are told that "(iron) protosulphate" is also called "green vitriol"; in the next paragraph we read of "ferrous sulphate"; in the next of "protosulphate (green copperas)"; in the next but one of "ferrous sulphate (green vitriol)"; and again, in the same paragraph, of "sulphate of iron." In ringing the changes which are possible with the names of this substance the author has in this short space hardly omitted one. The article on the electro-deposition of silver is very full and very useful. The quantity of silver used in plating wares which are sent in such large quantities to the colonies is stated to be about one ounce to the square mile! In Birmingham iron snuffers are sometimes "silvered" wholesale at

as low a price as fourpence per pair, and hooks and eyes at one penny per pound. They manage these things better in France, where electro-plating is regulated by law, the manufacturer being required to weigh each article when ready for plating, in the presence of a comptroller appointed by the Government, and to report the same article for weighing again when the plating has been done. Electro-gilding does not appear to be a costly process; a silver thimble may be handsomely coated, so as to have the appearance of being all gold, for threepence. Among the recipes for cleaning silver we find no mention of an excellent method in use for freshening the surface of filigree work. A plan which is recommended here is somewhat curiously worded: "Silver may be cleaned in water in which potatoes have been boiled, and a superior polish is thus imparted to them." Under copper we find some interesting particulars regarding the copying of wood engravings in that metal. Successful deposits of large wood blocks of the *Illustrated London News* have been formed and taken off in eight hours; and electrotype blocks used in printing *The Times* are stated to have furnished twenty million impressions before the surface was unfit for further use. As regards the deposition of nickel, to which attention has recently been drawn, we learn that although the metal is much less expensive than silver, the cost of nickel-plating is not proportionately less. In the Special Technical Section of the art of electro-metallurgy, the author describes the various forms of batteries in use; figures of the forms devised by Wollaston, Smee, and Daniell are provided, the batteries of Bunsen and Grove, however, are only illustrated by the coke bar used in the one, and the porous cell employed in the other. The use of batteries has in some cases been superseded by the introduction of magneto-electric machines and thermo-electric piles. A gramme machine, such as is employed by the firm of Christophle of Paris, when worked with one horse power at a speed of 300 revolutions per minute, will deposit 600 grammes of silver per hour. Clamond's pile, of the kind used in Birmingham, London, Sheffield, and other places, when burning 150 litres of gas per hour, will deposit one kilogramme of copper.

FERNS.*

THE study and cultivation of those interesting and often exquisitely beautiful plants, the Ferns, are now so very general that it need be no matter of surprise to find that the literature relating to them is constantly on the increase. We have now before us two excellent works on ferns. One of them is a new edition of Mr. John Smith's handbook of ferns, in which that gentleman, whose experience in this department of botany, and especially in the cultivation of the plants during his long service as Assistant Curator of the Botanic Gardens, at Kew, rendered him one of the first

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* "Ferns: British and Foreign. The History, Organography, Classification, and Enumeration of the Species of Garden Ferns. With a Treatise on their Cultivation, &c., &c." By John Smith, A.L.S. New and Enlarged Edition. 8vo. London: Hardwicke & Bogue. 1877.

"The Fern World." By Francis George Heath. 8vo. London: Sampson Low & Co. 1877.

authorities on the subject, gave a regular systematic account of all the cultivated British and foreign species of these plants. Mr. Smith, having the interests of the fern-grower especially before him, commences his work with a history of the introduction into this country of those exotic species which are or have been cultivated in our ferneries. His next section contains a brief but excellent organography of ferns, giving a description of the characteristic parts of the plants, to serve as an introduction to the systematic section of his work. In his classification he follows the "Species Filicum" of the late Sir William Hooker, and characterizes all the genera of ferns and fern-allies which possess species either native to this country or which have been cultivated here, the species, with their synonyms, being enumerated under each genus. In this new issue of his work Mr. Smith has added an appendix, in which the species introduced since 1866, the date of publication of his work, are treated in a similar fashion, the new information being brought into relationship with the old by means of the numbers of the genera. In the preparation of this appendix, which renders the work complete to the present date, the author has had the valuable aid of Mr. J. G. Baker and Mr. William Gower, of Kew. The work concludes with a long and elaborate chapter on the cultivation of ferns. Its descriptive section is illustrated with a great number of exceedingly good outline woodcuts, in which the characteristic parts of each genus are well shown, whilst a frontispiece furnishes similar illustrations to the general organography. To the student of ferns Mr. Smith's work, with its careful descriptions, good figures, and copious synonymy, will prove a most valuable acquisition.

The second work to which we have to call attention, although it also deals to a considerable extent with fern-cultivation, is of a very different character. The author, Mr. F. G. Heath, some time ago published a very nice little book under the title of the "Fern Paradise," which was really, as he called it, "a plea for the cultivation of ferns," and the success which this deservedly met with has induced him to try his luck with a larger venture on the same track. Mr. Heath's "Fern World" will be a very acceptable drawing-room book, but at the same time it possesses certain qualities which ought to earn for it a better position. The author writes with great enthusiasm of the plants of the culture of which he has in a manner constituted himself an apostle—he carries his reader with him in search of them to the beautiful combes of Devonshire, and discourses with much pleasant unction on the joys of fern-hunting among scenes to which his favourite plants lend so much of their charm. But before indulging us with these glimpses of "Fernland" he lays before us a store of solid food in the shape of a brief but good sketch of the general structure, character, and mode of growth of ferns, with notes on their classification, distribution, uses, and folk-lore, followed by several chapters on the culture of the plants. The illustrations of this portion of the book consist of a few woodcut figures in the text. The section on ferny scenery is illustrated with four beautiful views of localities in Devonshire.

The last part of Mr. Heath's work, occupying rather more than half his volume, is devoted to a description of the British species of ferns. His descriptions are not formal, but sufficiently precise to enable the species to

be easily determined, and the author has avoided giving a detailed account of the numerous minute variations to which some of his favourites are subject, and has done wisely, as we think; but we cannot approve of his remarks on this subject, which would seem to convey to his readers that these minute distinctions are absolutely needless, whereas to a great extent they are only needless for his purpose. In other respects Mr. Heath's book is so good that we are sorry to see him making statements *ad captandum vulgus*. We would also suggest as an improvement to this section of the book the addition of a synopsis of the genera; at present the generic and specific characters are combined in the descriptions, and perhaps this arrangement may be retained with advantage; but such a statement of the characters of the genera as would enable the reader to understand what is meant by a genus, and what is the significance of the scientific names employed, would certainly place the work on a much higher footing. The descriptions are well illustrated by coloured figures of each species (generally reduced in size), produced by a photo-lithographic process from the objects themselves; they are generally well executed and very characteristic.

PHYSIOGRAPHY.*

IT needed very little of the prophetic spirit to foresee that the introduction of physiography into the syllabus of the Science and Art Department would be speedily followed by the publication of text-books of physiography. Dr. Mackay is first in the field, and as an experienced hand at geographical compilation, he has succeeded in producing a neat little work, which may be found useful to students who think of facing the May examinations at South Kensington. Whether any good will result from the substitution of physiography for physical geography, is quite another matter, with which Dr. Mackay has of course nothing whatever to do. It is believed by very high authorities that physiography, or the science of nature in general, offers the best means of introducing young people to a little knowledge of geology, biology, physics, chemistry, astronomy, and what not. But it must also be acknowledged that so comprehensive a subject can be mastered only by one who commands a good deal of scientific knowledge. Physiography is indeed, in one sense, the sum and substance of all natural science, though in another sense it may be regarded as the starting point of the scientific circle. With so much matter to compress into so little space, we are surprised to find that Dr. Mackay has a good deal to say about the Great Pyramids, and that he should think it worth while to advocate the use of the ancient sacred cubit against what he calls "the much vaunted French mètre." But our surprise culminates when we find him going out of his way to explain how a change in the inclination of the earth's axis might have brought about the Noachian deluge, and have indirectly affected the longevity of man!

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* "Physiography and Physical Geography." By the Rev. Alex. Mackay, LL.D., F.R.G.S. Small 8vo. Edinburgh and London: Blackwood & Sons. 1877.

"Physiography: an Introduction to the Study of Nature." By T. H. Huxley, F.R.S. Small 8vo. London: Macmillan. 1877.

The preceding notice was intended for insertion in our last number, but had to be omitted for want of space. We regret this the less as it enables us to notice at the same time the recently published handbook of the inventor of Physiography, Professor Huxley, which enables us to see more clearly what is his idea of the best mode of teaching the new science. It appears to us, after a careful perusal of his book, that the difference between Physiography and Physical Geography consists almost entirely in the form in which the facts and inferences are presented to the learner. There is literally nothing in the volume that might not, or indeed ought not, to be taught in any treatise on Physical Geography, although perhaps a greater development is given to the explanations of certain collateral matters, such as solar physics and the chemistry of the atmosphere and of water, than is absolutely necessary for geographical purposes; but instead of arranging his subjects in the dry systematic form usually adopted, commencing with an account of the cosmical relations of the earth and gradually descending to details, he starts from the concrete example of the Thames and its valley, and works out from this comparatively narrow limit to the general phenomena of the earth and the universe. In fact the Thames being his text he preaches a sermon on the natural phenomena presented by the world of which it forms a part. It is easy to follow the sequence of thought involved in this operation. Thus, the geography of the Thames and its basin being described, the source of its waters naturally comes next into consideration, and in connection with this the phenomena of the great circulation of water on the surface of the earth are treated of; the atmosphere as one link in the chain is then described, and the consideration of the composition of pure and natural waters leads directly to the explanation of the action of moving water, whether liquid or frozen, in disintegrating and degrading the land-surfaces over which it passes. The sea also is noticed as having its work to do in the same direction. On the other hand there are compensating agencies at work in the action of earthquakes and volcanoes, in the slow secular upheavals of the land, and in the action of living creatures, tending more or less directly to restore the equilibrium of land and water, and these having been discussed, the geological facts revealed by the study of the basin of the Thames can be profitably considered. Then, by a not unnatural transition from the Thames valley to what lies outside it, the author passes to a general consideration of the distribution of land and water on the surface of the globe, to an account of the figure and movements of the earth, and finally to a description of the phenomena presented by the sun, with especial reference to its influence, and that of the moon, upon the surface of our earth. As he says, "the sun is revealed as the grand prime mover in all that circulation of matter which goes on, and has gone on for untold ages, within the basin of the Thames; and the spectacle of the ebb and flow of the tide under London Bridge, from which we started, proves to be a symbol of the working of forces which extend from planet to planet, and from star to star, throughout the universe."

It is, in fact, this idea of starting from the familiar, and working outward to the larger conceptions, that is the ruling idea of Professor Huxley's plan in this little work. Of course, it is impossible to tell how much of the credit of producing it is due to Professor Huxley, and how much to Mr.

Rudler, who, as we are told, prepared the substance of the lectures on which the work is founded for the press, but certainly, between them they have produced a most charming little book, and one which, as a means of self-instruction for the young, we cannot but regard as the best guide extant to a general elementary knowledge of the phenomena of the world we live in. We should, however, doubt its fitness for use as a school book, although it may probably serve, as Professor Huxley seems to hope, as a guide to teachers in giving a course of instruction to their classes. We may add that the little volume is illustrated with a good many wood engravings, and with several useful maps printed in colours.

THE FLORA AROUND LONDON.*

FORTY YEARS have elapsed since the publication of the "Flora Metropolitana," during which period the nature of the vegetation of the London district has to a certain extent been altered, and in some places even destroyed, owing to the clearing, enclosing, and building which has been constantly going on there, so that the character of many of the localities mentioned by Mr. Cooper in the work above mentioned have changed, and the plants which formerly grew there have disappeared. Dr. de Crespigny has therefore conferred a benefit on the botanical student and collector of plants by the compilation of a new London flora.

Availing himself of the descriptive works on the subject, and supplementing the information derived from them by extensive personal investigations, the author has recorded more than 1,200 species of plants which have been observed within a radius of thirty miles around London. These are arranged in alphabetical order under flowering plants and cryptogams; their chief localities are given. A series of seventy-five localities is appended, with lists of the plants to be found in each of them, preceded by short descriptions of the physical features and other characters. The object of the author is to show the actual occurrence of plants at the present time, rather than their local history in the past, and thus to render his work a handy guide to the botany of the metropolitan districts. This unambitious purpose its arrangement particularly adapts it to fulfil: the general list will tell the student where he may expect to find any particular plant of which he is in want, and the list of localities will inform him what he ought especially to look for in visiting them; and as the book is so small that it may be easily carried in the pocket, it can hardly fail to prove exceedingly useful to the practical botanist.

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* "A New London Flora, or Handbook to the Botanical Localities of the Metropolitan Districts." By E. Ch. de Crespigny, M.D., M.R.C.S. 8vo. London: Hardwicke & Bogue. 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

MORPHOLOGY of the Human Teeth.—Dr. E. Lambert, of Brussels, after a careful study of the characters of the teeth in the different races of man, has formulated the important conclusions at which he arrives as follows:—

In the *white* race the triturating surface of the canines does not project beyond that of the other teeth; the two premolars are of equal volume; the first true molar is the largest; and the last, or "wisdom-tooth," the smallest.

In the *black* race all these peculiarities are reversed; the canines project beyond the adjoining teeth, the posterior premolar is larger than its fellow, and the true molars increase in size backwards.

In the *white* race the molars usually have only *four* cusps; in the black, *five*. If in the white race there are five, it is the first molar that has them; in the black race it is the last.

In the *yellow* race there is usually, as in the black, a slight increase in the size of the true molars from front to back, and there is a fifth cusp on the hindmost molar.

In the black race the incisors are larger in diameter than in the white, and the triturating surface of the canines is larger than in the adjoining teeth.

In the black race there is a slight diastema, which does not exist in the white, and the inner tubercle of the premolar is less developed than the outer, as in the Anthropoid apes. The first lower premolar, also, has often a feebly developed inner tubercle, which is another slight manifestation of resemblance to the apes.

In the black race the upper molars have the antero-posterior diameter equal to the bilateral; in the white it is always smaller, whilst the yellow race show an intermediate form.

There is more difference in the teeth between the black and yellow races than between the yellow and white; but the Malay branch, the type of the brown race of D'Omalius, seems to be transitional between the black and yellow with respect to the general volume of the teeth, the number of cusps of the large lower molars, and the tendency to increase of size in the molars posteriorly.

The American race, the red race of D'Omalius, which is usually united with the yellow, presents so nearly the same dentary characters as the black

race that Dr. Lambert unites the two. The Australians, Tasmanians, and New Caledonians in some respects present an exaggeration of the dentary characters of the African negro, and they are also more strongly prognathous.

The crania from the caves of Furfooz (Belgium) have the lower molars decreasing in size backward, as in the white race; and this is also the case with seventy neolithic crania exhumed at Hastières. But the palæolithic lower jaw from La Naulette (Belgium) approximates most to that of the Australian and New Caledonian races, thus showing a resemblance in the age of the mammoth between man in Belgium and the existing races of the antipodes.—(*Bull. Acad. Roy. Sci. Belg.* 1877, No. 5; and *Amer. Journ. Sci.* October 1877, p. 322.

ASTRONOMY.

Sun's Distance deducible from the British Transit Observations, December 9, 1874.—Those observations by the British observing parties, which of themselves suffice to give a determination of the sun's distance, have been skilfully dealt with by Captain Tupman, and the result may be regarded as at least affording a means of estimating the value of the method employed. The Astronomer Royal, indeed, believes (naturally enough, perhaps) that the result will be accepted as more trustworthy than any before obtained, or than the mean of the results obtained by all the best preceding observations. Time will show, we believe, as it did in the case of his Harton Colliery experiment for determining the earth's mean density, that astronomers will not accept a result whose wide discordance from former measures (closely accordant *inter se*) indicates that the method employed is defective. Full credit will be given to the Astronomer Royal for his success in demonstrating the untrustworthy nature of Delisle's method of observing transits for determining the sun's distance. Sir G. Airy's opponents, in the controversy of 1872–4, only rendered the defectiveness of Delisle's method probable by reasoning more or less depending upon theoretical considerations. He has succeeded in demonstrating the point practically—at some considerable cost to the nation, but that is merely a detail. Whether this view of the *gist* of his results is correct, or that which he himself adopts, can be inferred, we believe, from the following facts:—In 1854 Hausen deduced for the solar parallax 8″.916 (we refrain here and throughout our remarks from giving decimal figures beyond the third, as no reliance whatever can be placed upon them). Other results at that time ranged between the values 8″.80 and 8″.96. Amongst such results should specially be noted one which all Greenwich united to honour, Mr. Stone's deduction of 8″.92 as the most probable result of the transit of Venus observations in 1769. Latterly Professor Newcomb, of America, has carefully gone over the whole subject, selecting with special skill the methods on which most reliance can be placed,

and the best sets of observations. He has thus obtained the following six results from the six best methods:—

Lunar equation of the earth	8″.809
Lunar parallactic inequality	8″.838
Micrometric observations of Mars (1862) . .	8″.842
Meridian observations of Mars (1862) . . .	8″.855
Transit of Venus 1769 (Powalky's reduction) .	8″.860
Foucault's experiment on light	8″.860

Giving to these results their proper weights, Newcomb obtains as the most probable mean 8″.848, corresponding to 92,393,000 miles as the sun's mean distance. Leverrier, again, from the method which he considered would in the long run supplant all others, deduced the parallax 8″.86.

Sir G. Airy announces as the result of the British expeditions, so far as the Delislean method is concerned (for fortunately many British Halleyan observations in the south were made which will be of service when combined with similar observations in the north by other nations), a solar parallax of 8″.760, corresponding to a distance of 93,321,000 miles, or nearly a million miles more than the value regarded by American, Continental, and a large number of British astronomers as most probable, and three-quarters of a million miles outside the range of probable error in the former evaluation.

This of itself would show that the Delislean method is as untrustworthy as was asserted before the transit. But besides this evidence from the comparison of the new result with those before obtained, the results themselves on which the new estimate is based show by their wide range of discrepancy the unsatisfactory nature of the method of observation relied upon by Sir G. Airy. The combinations for ingress, which ought to agree closely with the observations for egress, differ from them by 0″.108, corresponding to a difference of about 1,100,000 miles in the estimated distance of the sun. Yet we are gravely assured that results differing thus widely *inter se* give a mean value which can be trusted as correct within 200,000 miles. In other words we are to regard Newcomb's distance based on twenty times as many observations by six better methods, as probably a million miles too small, and almost certainly 800,000 miles too small, on the strength of observations, divisible into two sections, whereof one gives a result more than a million miles greater than the result given by the other. It is altogether unlikely that astronomers will accept a conclusion of this kind.

Observations of Mars.—Very interesting spectroscopic observations of Mars have been made at Greenwich during the recent opposition approach, and also many valuable telescopic observations at Madeira by Mr. N. E. Green. The spectrum of Mars was compared with that of the moon on August 23 and September 26, when their altitudes were nearly equal. Several faint diffused bands (besides, of course, the dark Fraunhofer lines) were observed in the spectrum of Mars on both occasions, of which only the three strongest could be seen in the spectrum of the moon. "On September 12," says the report communicated by the Astronomer Royal, "when the large spot, called in Proctor's chart 'Dawes' Ocean,' occupied the centre of the disc, the spectrum of Mars was examined for the detection of local differences. The dark spot gave a much fainter spectrum than the rest of the disc, the con-

trast being very marked in the red and yellow, and less so in the violet; it showed, however, no lines or bands other than those seen in other parts. The spectrum of the polar spot and its neighbourhood were very bright from about D to F, but showed very little red; the north limb, on the contrary, gave a spectrum somewhat less bright in the green and yellow, but extending further into the red. The group round C seemed to be darker over 'Dawes' Continent' (the bright spot north of 'Dawes' Ocean') and less dark on the north limb. Bands *a* and B were seen, but no difference in their appearance from whatever part of the disc was examined; but being fainter than C, a slight difference was less likely to be detected." "On September 21 and 26, the absorption bands then measured were noticed to be very slightly fainter in the limb than anywhere else. The locality where they were most distinct was variously estimated as from 5″ to 6″ from the limb on September 21, and from 3″ to 4″ on September 26; as the definition was much better on the latter occasion the smaller estimation is more likely to be correct. The difference in intensity, except just on the limb, was exceedingly slight; but the point where the bands were estimated to be darkest was always found to be at the same distance from the limb." This points unmistakably, as it seems to us, to the conclusion that the whiteness near the limb results from the condensation of aqueous vapour into the form of visible cloud. "The red end of the spectrum of Mars was much fainter on or near the limb; but the violet seemed of the same intensity from all parts of the disc, and was visible about as far as in the spectrum of the moon. The observations were made by Mr. Maunder."

Mr. Green's drawings of Mars must be regarded as taking the place which has heretofore been accorded to Mr. Dawes' drawings of the planet. They certainly far surpass all yet taken in accuracy as well as in fulness of detail. He used a 13-inch silver-on-glass reflector, by With, and a fine 12½-inch speculum, by Messrs. Horne & Thornthwaite. Each drawing was made direct from the telescope, and entirely independent of those which had been produced previously, all comparison being reserved till the evening was over. In one region (that lying east of the De la Rue Ocean, in Proctor's chart—*see* our number for July, 1877) several important corrections have been made. In particular, the sea to which Mr. Proctor gave the name of Lockyer Sea, is shown to be far more strongly marked than the one to the north, called Dawes Sea. The narrow inlet connecting Lockyer Sea with De la Rue Ocean in Mr. Dawes' drawings has no real existence. Under unfavourable atmospheric conditions there appears to be an inlet; but when the definition is good the appearance is found to be due to the presence of a small lake lying in the line of the supposed connection.

"It has been remarked," says Mr. Green, "that the snow caps do not agree exactly with the poles of the axis of revolution. It may be a confirmation of this statement to mention that by September 18, the snow zone," which a week before had appeared large and distinct, "was considerably reduced in size, and its outline very indefinite, whereas by the end of the month it had returned in great measure to its previous form and size; the rapidity and extent of this change being greater than could be attributed to simple alterations of temperature."

An amusing episode occurred after the reading of Mr. Green's paper at the

Astronomical Society, a foolish person starting the theory that the ruddy colour of Mars is due to heat, or rust, we forget at the moment which. The dignity with which the President explained that, owing to the lateness of the hour the theory need not be discussed, was delightful to all save the theorist, who did not appreciate, perhaps did not fully understand the joke.

The Satellite of Neptune seen with a 4½-inch Object-glass.—Mr. J. W. Ward, of Belfast, whose observations of the two outer satellites of Uranus with a 4½-inch achromatic, excited considerable attention in the spring of 1876, has achieved what might be supposed the still more surprising feat of observing the satellite of Neptune with the same telescope. It appears, however, that he finds the satellite of Neptune as easy to see, or rather he finds it not more difficult to see, than the two outer satellites of Uranus, whence we must infer that Neptune's satellite is a far larger body than any of the satellites of Uranus.

Lunar Inequalities.—Mr. Neison writes to us as follows:

"Sir,—In the October number of the 'Popular Science Review' I find a statement about myself which is entirely untrue, and which, therefore, I beg of you to be so good as to give me the opportunity of contradicting in the next number of the 'Review.' These statements had been already made in another periodical and denied by me, and I refer you to the enclosed copy of the November number of the "Astronomical Register" for a detailed proof that they are perfectly unfounded.—Yours faithfully, E. Neison."

Our remarks were very moderate, the strongest words we used being in a sentence to the effect that Mr. Neison's procedure seemed to us ill-considered. We brought no "railing accusation" against him. It is in his power, we have no doubt, to remedy the mistake so far as it affects himself by original research.

Proper Motions and Distances of the Fixed Stars.—M. Flammarion who has lately achieved notoriety by his new chart of Mars based on M. Terby's researches, announces two sets of results of what he describes as his original researches into sidereal astronomy. In the first place, by charting the proper motions of the fixed stars, he finds reason to believe that some of these bodies are travelling together through space. In the second place, he says, after describing the theories of Sir W. Herschel, Struve, and others, 'les recherches que j'ai entreprises m'ont lentement et successivement amené à des conclusions toutes différentes, dont voici le résumé. Les plus grandes différences d'éclat intrinsèque, de dimensions, et de masses, existent entre les étoiles. Il y a peut-être autant de différences entre les étoiles qu'entre les planètes de notre système. Ainsi la distribution générale des étoiles n'offre pas la régularité classique sous laquelle on l'envisageait; de petites étoiles, des amas, et des nébuleuses, peuvent être moins éloignés de nous que des étoiles brillantes; et la constitution des cieux présente un caractère moins simple que celui qui lui était assigné par des jauges télescopiques et la théorie d'une distribution homogène.' The following passages in an essay by Mr. Proctor would therefore seem to be plagiarisms of M. Flammarion's later views on these points:—"The charting of the stellar proper motions has led me to the discovery of the fact that the stars in many parts of the heavens are travelling in systems—or, as it were, drifting—through space" . . . instances cited . . . "The general conclusions to which I

have been led by these and other methods of research are chiefly these: The sidereal system is altogether more complicated, altogether more varied in structure than has hitherto been supposed. Within one and the same region co-exist stars of many orders of real magnitude . . . All the nebulæ hitherto discovered exist within the limits of the sidereal system." And so forth. Mr. Proctor's offence is not one of yesterday. The paper from which we have quoted appeared in the "Quarterly Journal of Science" for July 1872; but since August 1867 (*see* "Intellectual Observer" for that date) Mr. Proctor has been thus unfairly describing as his, results which were in reality promulgated by M. Flammarion in 1877. Nay, some were announced even earlier by M. Flammarion. For instance, in 1870 Mr. Proctor described the drift of five stars of the seven forming "the Plough." Now as far back as 1873 this had been described by M. Flammarion in an article entitled "The future of a constellation." M. Flammarion seems to think not "Pereant qui, &c.," but "Periêrunt qui ante nos nostra dixerint."

De Vico's Comet.—This comet of short period should have returned to perihelion this year according to the calculations of Professor Brünnow. As it has not been seen, Mr. Hind considers that "we must probably place the comet in the class which though undoubtedly moving in elliptical orbits of small dimensions when under observation, are now 'lost.'" "But whether this arises from a larger error in the determination of the mean motion in 1844 than at present appears admissible, or whether the action of the planet Mars may explain it, or, again, whether the comet has encountered one of the minor planets, and thereby been deflected or disintegrated, cannot be at present ascertained."

Phenomena for the Quarter.—Venus will be at her greatest brilliancy as an evening star on January 16, in inferior conjunction with the sun at 5 a.m. February 21, and at her greatest brilliancy as a morning star on March 29. The disappearance and reappearance of Saturn's rings on February 6 and March 1 respectively, will not be observable, owing to Saturn's proximity to the sun, Saturn being in conjunction with the sun on March 13 at 6 p.m. On February 16, at 5 a.m., Uranus will be in opposition. Neither the solar eclipse of February 1, nor the lunar eclipse of February 16, will be visible in this country.

BOTANY.

Germination of Megarrhiza californica.—Dr. Asa Gray finds that the germination of this cucurbitaceous plant, which is allied to *Echinocystis*, presents certain peculiarities which he describes ("Silliman's Journal," July 1877). The seeds came up in the manner of beans, the body of the seed in its shell being raised well out of the soil upon what seemed to be a well-developed radicle, like that of *Echinocystis*, but no plumule made its appearance from between the fleshy cotyledons. On the contrary, in about a fortnight, in all three of Dr. Gray's young plants, the plumule pushed separately out of the soil of the pot, and, on the whole plant being exposed, it was found to spring from the base of what appeared to be an elongated radicle (two or three inches long), and below it the thickening of the root, which is a

striking character of the species of *Megarrhiza*, had already made considerable progress. The plumule issued from a cleft at the base of the seeming radicle, through which a considerable amount of the nutriment stored in the cotyledons must have been carried down to assist the growth of the root and plumule. From further investigation it appeared that the supposed radicle was really formed by two connate petioles of the cotyledons, not present in the seed.

CHEMISTRY.

Liquefaction of Nitric Oxide, Marsh Gas, and Oxygen.—The close of last year will be remembered as the occasion of the announcement of two important discoveries in physical chemistry. Cailletet has succeeded in liquefying nitric oxide. This gas which, it had previously been found, would not change its state of aggregation if cooled to −110° C. or subjected to a pressure of 50 atmospheres ("Compt. rend." 1877, p. 1016), becomes liquid under a pressure of 104 atmospheres at −11° C. He finds, moreover, that at 8° C. the dioxide remains gaseous under pressures equal to 270 atmospheres. Berthelot submitted some gases to a pressure of 800 atmospheres without inducing a change. The cause of this has been explained by Andrews, who has traced the connection which exists between the properties of a so-called permanent gas and those of liquids which condense almost without change of volume. He finds that for each vapour there exists a critical point of temperature, above which the vapour cannot be converted into a liquid by any pressure however great it may be. Cailletet also communicates some interesting results of experiments made for the purpose of liquefying marsh gas. He noticed that at a temperature of 7° C. and under a pressure of 180 atmospheres the gas under examination becomes *cloudy* and exhibits the same appearance as has been observed in the case of liquid carbonic acid when the pressure has been suddenly reduced. There appears little doubt that this was condensed marsh gas, which rapidly evaporated when it came in contact with the glass and mercury of the apparatus. It is not at all improbable, therefore, that Cailletet will before long succeed in removing light carburetted hydrogen from the list of permanent gases. The "Journal de Genève" of the 23rd December (see the "Times," 26th December, 1877), announces the liquefaction of oxygen by Raoul Pictet. The process adopted appears, from the short extract referred to, to have consisted in subjecting the gas to great pressure and a low temperature produced by the evaporation of solid carbonic acid. The latter gas was first liquefied at a temperature of −65° C. and under a pressure of from four to six atmospheres by the aid of sulphurous acid. The carbonic acid was then placed in a long tube connected with two pumps acting together, and the exhaustion continued till the acid became solid. Through this tube containing the frozen gas, passed another of very fine bore, along which a current of oxygen, prepared from potassium chlorate, was conveyed. The pressures to which the oxygen could be subjected reached as high as 800 atmospheres. At a pressure, however, which it is stated did not exceed 300 atmospheres, the gas was liquefied, and a jet of liquid oxygen was projected from the extremity of the fine tube at

the instant that the compressed and cooled gas exchanged the intense pressure for that of the atmosphere.

Plant Chemistry.—Professor Church has examined colein, the red colouring matter of *Coleus Verschaffeltii*, and is inclined to think that it is identical with œnolin, obtained from red wine, as well as with the substances anthocyan, erythrophyll and cyanin, which have been extracted from blue and purple flowers. Colein is soluble in alcohol, but insoluble in ether; acids turn its solutions red, while alkalies strike a violet, indigo-blue, green, and, finally, yellow colour. The formula of colein is $C_{10}H_{10}O_5$; the salts which it forms with lead, barium, and other metals, have been prepared. It appears to be present in the copper-beech and the grape, and it is perfectly distinct in its characters from the colouring-matter of the red beet. The composition of the flowers of *Fraxinus excelsior* has also been investigated by Professor Church. He found the ash to contain 39·42 per cent. of potash, 13·22 per cent. of lime, and 28·98 per cent. of phosphoric acid. The ash-flowers contain 7·4 times as much nitrogen, 7·7 times as much potash, and 10·5 times as much phosphoric acid as has been found in the leaf-scales of the beech. His paper ("Journal of Botany," 1877, vi. 346) contains, moreover, some interesting observations on the composition of the leaves of a variegated form of *Acer Negundo*. The ash of the white and green portions were analysed separately with the following results:—

Percentage in Ash of	White Parts.	Green Parts.
Potash	40·05	12·61
Lime	10·89	39·93
Magnesia	3·96	4·75
Phosphoric Acid	14·55	8·80

These figures seem to show that the white leaves, or parts of leaves, of this maple differ from the green leaves much in the same way that young leaves differ from old.

The Behaviour of Sulphates with Melted Sulphur.—Sestini has shown that gypsum when heated with sulphur decomposes in accordance with the equation:—

$$CaSO_4 + 2S = 2SO_2 + CaS.$$

Violi has since observed that this reaction appears to be a general reaction as regards the sulphates. Sulphates of the metals of the alkaline earths, as well as those of aluminium, chromium, zinc, manganese, iron, cadmium, lead, bismuth, copper, antimony, and mercury, are converted into sulphides in accordance with the equation, $RSO_4 + 2S = RS + 2SO_2$. The author recommends this method for the formation of a metallic sulphide, and also as a source of sulphurous acid (*Ber. Deut. Chem. Gesell.*, x. 293).

Preparation of Nitrogen.—It has been observed by Gatehouse ("Chemical News," xxxv. 118) that ammonium nitrate and manganese peroxide, when heated together at a temperature of 165°–200° C., evolve a constant current of an invisible gas, which neither burns nor is absorbed by potash pyrogallate. The gas proves to be pure nitrogen, formed in accordance with the equation:—

$$4NH_4NO_3 + MnO_2 = Mn(NO_3)_2 + 8H_2O + 6N.$$

320 grammes of ammonium nitrate gave 67·14 litres of nitrogen, at the normal temperature and pressure. In one experiment where 3 grammes of nitrate were heated with the requisite amount of manganese peroxide in a mercury bath at 205° C., they yielded 606 cub. cent. of nitrogen; the theoretical amount is 630 cub. cent. At higher temperatures than 215° C. the reaction appears to be a complex one, the manganese nitrate being broken up into manganese oxide, hyponitric acid, and oxygen.

The Estimation of Nickel.—A paper on this process, written by Margaret S. Cheney, and Ellen Swallow Richards, and dated from the "Women's Laboratory, Massachusetts' Institute of Technology," appears in the "Amer. Journ. Sci.," 1877, xiv. p. 178. The authors having occasion to determine quantitatively the amount of nickel in some pyrrhotites and matts were led to examine the accuracy of the various methods proposed for the separation of that metal from iron. They found that which is known as the acetate process to be a tedious one, and the plan for the removal of the iron with ammonium hydrate very unsatisfactory: but good results were obtained by the process proposed by Field in 1859, who employed lead oxide to effect the complete separation of the metals. In the case of the nickel, which they weighed as oxide, the analytical numbers were too high—a result which was to be expected; and they were finally led to adopt a process based on the fact that nickel phosphate is completely soluble, while iron phosphate is almost insoluble, in acetic acid, in presence of an excess of sodium phosphate. After the metals which are thrown down by sulphuretted hydrogen have been removed, and the filtrate has been boiled to drive off the excess of that reagent, the iron is oxidized with nitric acid, and ammonium hydrate is added until a permanent precipitate begins to form, but not until complete precipitation of the iron oxide is effected. Acetic acid is then added to re-dissolve the oxide, and the deep-red coloured solution raised to the boiling point. An excess of ordinary sodium phosphate is then added to it, and the nearly white precipitate is filtered off and washed with hot water containing acetic acid. The filtrate is heated nearly to the boiling point, and caustic potash is added to it till the odour of ammonia is distinctly perceptible. The apple-green precipitate of nickel phosphate is partially washed, dissolved in a little *dilute* sulphuric acid, the solution rendered strongly alkaline with ammonium hydrate, and the nickel precipitated with the battery; a current from two quart cells charged with bichromate and sulphuric acid sufficed in two hours to completely precipitate the metal. The numbers fall only a little short of those required by theory, amounting in three experimental determinations to 99·06, 99·33, and 99·73 per cent. respectively.

Absorption of Carbonic Oxide.—Böttinger finds that carbonic oxide, when conducted through hydrocyanic acid cooled to a low temperature, is abundantly absorbed by that liquid; if concentrated hydrochloric acid be added to the solution, the two liquids will not mix. When the vessel containing them is removed from the freezing mixture, a constant current of pure carbonic oxide is evolved; on the subsequent application of heat the evolution of gas becomes stronger, while the gas itself is contaminated with hydrocyanic acid; finally the liquids mix and a turbulent disengagement of gas is the result, pure unaltered hydrocyanic acid remaining in the vessel.—*Ber. Deut. Chem. Gesell.*, 1877, x. 1122.

Synthesis of Hydrocarbons.—Friedel and Crafts have recently published a valuable series of papers on a new method, of general application, for the synthesis of hydrocarbons, acetones, &c. ("Journ. Prakt. Chem.," 1877, xvi. p. 233.) The chemical changes are brought about by the action of aluminium chloride. When to amylic chloride dissolved in benzol some of the metallic chloride is added, hydrochloric acid is set free, and amyl-benzol is formed:—

$$C_5 H_{11} Cl + C_6 H_6 = H Cl + C_6 H_5 (C_5 H_{11}).$$

If an organic bromide or iodide be taken in place of a chloride, a similar reaction is noticed: ethylic iodide, for example, in the presence of benzol and the metallic chloride forms hydriodic acid and ethyl-benzol:

$$C_2 H_5 I + C_6 H_6 = H I + C_6 H_5 (C_2 H_5).$$

Methylic chloride dissolved in benzol under similar conditions produces toluol; and when two, three, or four molecules of methylic chloride react on one molecule of benzol in presence of aluminium chloride, xylol, mesitylen and durol are produced, a corresponding number of molecules of hydrochloric acid being set free. Under similar circumstances benzylic chloride yields diphenylmethane. Bodies containing more than one atom of chlorine are also acted upon in a like sense when in contact with benzol and the metallic chloride; chloroform produces triphenylmethane, and carbon tetrachloride tetraphenylmethane. Benzoic and acetic chloride form respectively benzophenon and acetophenon. Other metallic chlorides resemble that of aluminium in their ability to withdraw hydrochloric acid; iron perchloride acts at ordinary temperatures, and iron protochloride when heat is applied. The authors are of opinion that in the first stage of the reaction, which we have considered, an organic compound containing aluminium is formed, which then undergoes decomposition, setting the aluminium chloride once more free. The case where benzylic chloride enters into the reaction, for example, would be represented thus:—

$$C_6 H_6 + Al_2 Cl_6 = H Cl + \underbrace{Al_2 Cl_5, C_6 H_5}_{\text{hypothetical compound.}}$$

$$Al_2 Cl_5 (C_6 H_5) + (C H_2 C_6 H_5) Cl = Al_2 Cl_6 + \underbrace{(C H_2 C_6 H_5) C_6 H_5}_{\text{Diphenylmethane.}}$$

Phosphorescence of the Salts of Quinine.—It has been noticed by Landerer ("Ard. Pharm.," [3] x. p. 322) that quinine sulphate becomes phosphorescent at 40° to 50° R. If some of the salt, strewn over a sheet of smooth paper, be placed on a plate of metal and exposed to this temperature, it becomes beautifully phosphorescent when stirred with a glass rod, the light being observed for some minutes. Valerate of quinine exhibits the same phenomenon, even when heat is not applied; if a few crystals be rubbed or struck in a mortar a luminous appearance is observed with each blow of the pestle. The phenomenon, it seems, is only noticed when use is made of valerate containing acid which has been prepared directly from the root of the valerian.

Polyporic Acid.—This acid has been obtained by Stahlschmidt from several species of *Polyporus* ("Annalen der Chemie," 1877, clxxxvii. p. 177).

It appears to be quite insoluble in water, so that the addition of a few drops of a mineral acid to an aqueous solution of the merest trace of a polyporate causes the liquid to become turbid; it is proposed to make use of this delicate reaction in alkalimetry in place of a colour test. The salts of the acid are well-defined compounds, some of which, as the polyporates of potash, soda, and ammonia, form deep purple-coloured solutions. The empirical formula of polyporic acid appears to be $C_7 H_9 O_2$. When the potash salt is heated to redness with zinc-powder, benzol is formed.

Platinum Black.—A ready method of preparing the metal in a form which exhibits unusually active catalytic properties has been described by Böttger ("Pharm. Centralbl.," xviii. p. 218). He adds to a solution of platinic chloride sufficient seignette salt (potassium sodium tartrate), and heats the mixture to the boiling point; a brisk evolution of carbonic acid takes place, and in a very short time all the metal separates from the solution; it has then to be washed and dried at a moderate temperature. The finely-divided metal prepared in this way readily converts alcohol into acetic acid, and ignites illuminating gas when placed in contact with gun-cotton.

GEOLOGY.

A New Order of Fossil Reptiles.—The researches of American explorers in that apparently inexhaustible mine of palæontological novelties, the Far West, have furnished Professor Marsh with a great portion of the skeleton of a huge reptile, which he regards as one of the most remarkable animals yet discovered. It was obtained on the eastern flank of the Rocky Mountains, in beds which may be regarded as nearly corresponding to the Wealden or else as Upper Jurassic. The animal, which Professor Marsh denominates *Stegosaurus armatus*, probably measured about thirty feet in length, and moved mainly by swimming. It possessed teeth with compressed crowns, inserted in sockets, and measuring nearly four-and-a-half inches in length and nearly an inch in greatest diameter. Besides these there are numerous cylindrical tooth-like organs, about three inches long and three-fifths of an inch in diameter, which were placed in rows, either in thin plates of imperfect bone or in cartilage. These, the author thinks, may prove to be dermal spines with the characters of teeth, such as occur in some fishes. The body was long and protected by bony plates, which appear to have been in part supported by the elongated spines of the vertebræ, which are coossified with the biconcave centra. One of the dermal plates was more than three feet long. Professor Marsh regards this remarkable reptile as the type of a new order, which he names *Stegosauria.*—*Amer. Journ. of Sci.*, Dec. 1877.

New American Jurassic Dinosaurs.—The Dinosaur described by Professor Marsh under the name of *Titanosaurus montanus*, as from the Cretaceous deposits of Colorado (see "Pop. Sci. Rev.," Oct. 1877, p. 424), is now found to belong to a lower geological horizon, and is really from the Upper Jurassic. Professor Marsh now changes its name from *Titanosaurus* to *Atlantosaurus*, the former being preoccupied, and states that additional remains which have been obtained, show that it is the type of a distinct family, which he calls *Atlantosauridæ*. The femur of *Atlantosaurus montanus* is about seven

feet long, so that if the animal had the proportions of a Crocodile it was at least eighty feet in length. Two nearly allied species, also with large pneumatic cavities in the centra of the vertebræ, form the new genus *Apatosaurus*; one of them, *A. ajax*, is supposed to have been between fifty and sixty feet, and the other, *A. grandis*, at least thirty feet long. The femur of the latter measures about three feet four inches. These are from a somewhat lower horizon than the *Atlantosaurus*. *Allosaurus fragilis* is a third new species, also with deeply excavated vertebral centra, which are biconcave. The bones of the feet are very slender. The animal, which is from the same locality as the preceding, was from fifteen to twenty feet in length. With these are the remains of a small Dinosaur, about as large as a Fox, described by Professor Marsh as *Nanosaurus rex.—Amer. Journ. Sci.*, Dec. 1877.

A Fossil Branchipus.—Mr. Henry Woodward has detected in some Eocene freshwater limestones from Gurnet Bay, Isle of Wight, numerous remains of delicate little Crustaceans of the genus *Branchipus* or *Chirocephalus*. The animals are beautifully preserved, the males exhibiting their large clasping antennæ, and the females their egg-pouches. Mr. Woodward names this interesting little Crustacean, the first of its kind that has undoubtedly been found fossil, *Branchipodites vectensis*. The Branchipods are accompanied in the deposit by two species of Isopod Crustaceans, by several bivalved Entomostraca, and by a great number of the remains of insects belonging to nearly all orders.—*Proc. Geol. Soc.* Dec. 19, 1877.

Fossil Plants from Grinnell Land.—Near Discovery Harbour, where H.M.S. *Discovery* wintered in 1875-6, in about 80° 45′ N. lat., and 64° 45′ W. long., a bed of lignite, from 25 to 30 feet thick, was found, resting unconformably upon the azoic schists of which Grinnell Land chiefly consists. The lignite was overlain by black shales and sandstones, the former containing many remains of plants; and above these there were, here and there, beds of fine mud and glacial drift, containing shells of marine Mollusca of species now living in the adjacent sea. This glacial marine deposit occurs up to levels of 1,000 feet, indicating a depression and subsequent elevation of the region to at least this extent. Of the remains of 25 species of plants collected by Captain Feilden, and submitted by him to Professor Oswald Heer, 18 are already known from Miocene deposits of the Arctic zone. The deposit is therefore no doubt Miocene. It has 17 species in common with Spitzbergen (78° 79′ N. lat.), and 8 species in common with Greenland (70° 71′ N. lat.). With the Miocene flora of Europe it has 6 species in common; with that of America (Alaska and Canada) 4; with that of Asia (Sachalien) 4 also. The species found include 2 species of *Equisetum*, 10 Coniferæ, *Phragmites œningensis*, *Carex noursoakensis*, and 8 Dicotelydons, namely, *Populus arctica*, *Betula prisca* and *Brongniarti*, *Corylus Macquarrii* and *insignis*, *Ulmus borealis*, *Viburnum Nordenskiöldi*, and *Nymphæa arctica*.

Of the Conifers, *Torellia rigida*, previously known only by a few fragments from Spitzbergen, is very abundant, and its remains show it to have been allied to the Jurassic genera *Phœnicopsis* and *Baiera*, the former in its turn related to the Carboniferous *Cordaites*, and among recent Conifers, to *Podocarpus*. Other Conifers are *Thuites Ehrenswardi*?, *Taxodium distichum*

miocenum (with male flowers), *Pinus Feildeniana* (a new species allied to *P. Strobus*), *Pinus polaris*, *P. abies* (twigs covered with leaves), a species of *Tsuga* (*Pinus Dicksoniana*, Heer.), and a white Spruce of the group of *Pinus grandis* and *cariocarpa*. *Pinus abies*, which occurs here and in Spitzbergen, did not exist in Europe in Miocene times, but had its original home in the extreme north, and thence extended southwards; it is met with in the Norfolk forest-bed, and in the interglacial lignites of Switzerland. Its present northern limit is 69½° N., and it spreads over 25° of latitude. *Taxodium distichum*, on the contrary, spread in Miocene times from Central Italy to 82° N. latitude, whilst at present it is confined to a small area.

Betula Brongniarti, Ett., is the only European species from Grinnell Land not previously known from the arctic zone.

The thick lignite-bed of Grinnell Land indicates a large peat-moss, probably containing a lake in which the water-lilies grew; on its muddy shores stood the large reeds and sedges, the birches, poplars, *Taxodia*, and *Torelliæ*. The drier spots and neighbouring chains of hills were probably occupied by the pines and firs, associated with elms and hazel-bushes. A single elytron of a beetle (*Carabites Feildenianus*) is at present the sole evidence of the existence of animals in this forest region.

The nature of the flora revealed by Captain Feilden's discoveries seems to confirm and extend earlier results. It approaches much more closely to that of Spitzbergen than to that of Greenland, as might be expected from the relative positions of the localities; and the difference is the same in kind as that already indicated by Professor Heer between Spitzbergen and Greenland, and would indicate the same kind of climatic difference. Nevertheless, the presence of *Taxodium distichum* excludes arctic conditions, and that of the water-lily indicates the existence of fresh water, which must have remained open a great part of the year. Representatives of plants now living exclusively in the arctic zone are wanting in the Grinnell Land deposits; but, on the other hand, most of the genera still extend into that zone, although they range in Grinnell Land from 12° to 15° further north than at present.—*Proc. Geol. Soc.*, 7th November, 1877.

European Tertiary Deer.—In a paper lately read before the Geological Society, Professor W. Boyd Dawkins discussed the characters presented by the European Miocene and Pliocene Deer, and indicated that the majority of the known antlers may be referred to two categories—an earlier or Capreoline, and a later or Axidine type. To the CAPREOLI he referred the following species:—*Dicroceros elegans*, Lart., = *Prox furcatus*, Hemel, *Cervus dicranoceros*, Kaup. (including *C. anoceros* and *trigonoceros*, Kaup.), and *Cervus Matheronis*, Gerv. (= *C. Bravardi*) from the Miocene, and *Cervus australis*, Gerv., and *C. cusanus*, Croizet & Jobert, from the Pliocene. To the AXEIDES belong *Cervus Perrieri*, Cr. & Job. (including *C. issiodorensis* and *pardinensis*, of the same authors), *C. etneriarum*, Cr. & Job. (= *C. rusoides*, Pom., and *C. perollensis* and *stylodus*, Brav.), *C. suttonensis* sp. n., and *C. cylindroceros* Brav. (including *C. gracilis*, Brav.), all from Pliocene deposits. Besides these, the author noticed a species *incertæ sedis* under the name of *Cervus tetraceros*, Dawkins, which he regards as coming nearest to the Virginian Deer, or Cariacou (*Cariacus virginianus*). From the examination of the antlers of these species he indicates that in the Middle Miocene

age the cervine antler consisted of a simply forked crown, whilst in the Upper Miocene it became more complex, although still small and erect, like that of the Roe Deer. In the Pliocene it becomes larger and more complex, some forms, such as the *Cervus dicranios*, Nesti, being the most complicated of known antlers. The successive changes are analogous to those observed in the development of the antlers of the living deer with increase of age. In the Miocene we have the zero of antler-development, and the Capreoline type is older than any other. The nearest living analogue of the Miocene Deer is, according to the author, the Muntjak (*Styloceros*), now found only in the oriental region of Asia, along with the Tapir, which also coexisted with *Cervus dicranoceros* in the Miocene forests of Germany. The Pliocene Deer, again, are generally most nearly allied to the oriental Axis and Rusa Deer, the only exception being *Cervus cusanus*, the antlers of which resemble those of the roe, an animal widely spread over Europe, and Northern and Central Asia. The alliance of these Pliocene Deer with those now living in the Indian region is regarded by the author as a further proof of the warm climate of Europe in Miocene times, confirmatory of the conclusions arrived at by Saporta from the study of the vegetation.

A New Bird from the London Clay.—Professor Owen has recently described before the Geological Society some remains of a large bird obtained by Mr. W. H. Shrubsole from the London Clay of Sheppey, consisting of parts of fractured humeri, belonging to the right and left side of the same species or perhaps individual, and including the head of the bone, with portions of the upper and lower parts of the shaft. The texture of the shaft, the thinness of its bony wall, and the large size of the cavity recall the characters of the wing-bones of the large Cretaceous Pterodactyles. The author indicated the characters which led him to regard the remains under consideration as those of a volant bird, most nearly approaching the genera *Pelecanus* and *Diomedea*; and as the evidence derived from the cranium of *Dasornis* would indicate a bird too large to be upborne by wings to which these bones might have belonged, whilst the skull of *Odontopteryx* is far too small to have formed part of a bird with wings as large as those of the Albatross, and *Lithornis* and *Pelargornis* are excluded by the characters of their remains, the author concluded that the bones obtained by Mr. Shrubsole furnished indications of a new genus and species of flying birds, for which he proposed the name of *Argillornis longipennis*. He regarded it as probably a long-winged natatorial bird, most nearly related to *Diomedea*, but considerably exceeding the Albatross (*D. exulans*) in size.—*Proc. Geol. Soc.*, 19 Dec. 1877.

A Fossil Fungus.—Mr. Worthington G. Smith has given a long description, with figures ("Gardener's Chronicle," 1877, p. 499) of what appears to be a parasitic fungus allied to *Peronospora*, found traversing the scalariform axis of a *Lepidodendron*. The mycelium is formed by slender threads with numerous joints or septa, and bears upon short branches a considerable number of spherical oogonia or zoosporangia, within many of which the zoospores can be clearly distinguished. Singularly enough, both the oogonia and their contained zoospores are of precisely the same size as the corresponding organs in the existing *Peronospora infestans*, the fungus of diseased

potatoes. For this parasite Mr. Smith proposes the name of *Peronosporites antiquarius.** *Peronospora* is one of those low forms, the true position of which is exceedingly doubtful. If not an Alga, it is exceedingly nearly related to the Algæ, and we may remind our readers that some two years ago Professor Duncan described before the Geological Society ("Quarterly Journal of the Geological Society," vol. xxxii., p. 205) the occurrence in fossil shells and corals even as low down in the series of formations as the Silurians, of parasitic mycelia bearing sporangia, very similar in many respects to the organisms described by Mr. Smith. He regarded these filamentous plants as Algæ, nearly related to the existing genus *Achlya*, and named the species, *Palæachlya perforans*. Mr. Carruthers, at a still earlier period ("Quarterly Journal of the Geological Society," vol. xxvi., p. 351) noticed the occurrence of mycelial threads, which he referred to *Peronospora*, among the cells of his *Osmundites Dowkeri*, an Eocene fossil fern from Herne Bay. References to previous observers of similar perforant organisms in recent and fossil shells, and other hard parts of animals, will be found in Professor Duncan's paper above referred to. Professor Kölliker regarded the parasites observed by him in recent shells as Fungi.

METEOROLOGY.

A Third Diurnal Barometric Maximum in Winter.—M. Rykatchev announces ("Bull. Acad. Sci. de St. Petersb.," tome xxiv., No. 1, p. 108) that throughout the temperate zone of the northern hemisphere the barometer in winter, and especially in the month of January, shows a third maximum, or at least a greater or less rise between one and two o'clock in the morning. He gives a table showing the diurnal course of the barometer at numerous stations in Europe, Asia, and North America, in support of his statement. His third maximum is greatest between latitudes 40° and 45° N.; in the tropics it is not observed. M. Rykatchev takes occasion to point out from the occurrence of this maximum the necessity of day and night observations of the barometer at all stations, seeing that the barometric curves drawn in accordance with Bessels' formula from day observations alone give no indication of it.

MINERALOGY.

Coloradoite.—Closely following on Krenner's announcement of the occurrence of bunsenine (gold telluride) at Nagyág comes the discovery by Genth of a new telluride, to which he has given the above name. ("Amer. Journ. Sci.," 1877, xiv. p. 423). It has been met with in the Keystone and Mountain Lion Mines of Colorado. The new species is not crystallized, and has an iron black colour and metallic lustre; its composition has been found to be

Mercury	60·98
Tellurium	39·02
	100·00

* *Antiquus* would be a better specific name.

which numbers correspond with the formula Hg Te. In the same mine, the Keystone Mine, where this mercury telluride occurs, two more new minerals have been discovered. One, which has been named *magnolite*, is found in bundles or tufts of white silky needles; they appear to have the composition indicated by the formula Hg_2 Te O_4. The second, *ferrotellurite*, forms delicate tufts of minute prismatic crystals of a straw and lemon-yellow colour; their composition is probably represented by the formula Fe Te O_4.

Cassinite.—Genth, in his Report on the Mineralogy of Pennsylvania, states that while the minerals, lenilite and delawarite, which Lea regarded as varieties of orthoclase, are identical with orthoclase, cassinite, on the other hand, which Lea had also included in the same category, proves to be of interest from the fact of its containing 4 per cent. of baryta. The density of cassinite is 2·692, and the analytical results which Genth has published show the oxygen ratios for (R_2 O + R O) : R_2 O_3 : Si O_2 to be 1 : 3 : 10.7. His results are of interest when compared with those of Des Cloizeaux on baryta-felspar.—*Zeitschrift für Krystall. und Mineralogie*, 1877, 1298.

Venerite, a New Copper Ore.—This ore occurs in the Jones Mine, near Springfield, Caernarvon Township, Berks County, Pennsylvania, a locality which has long been known for extensive deposits of magnetite, with more or less chalcopyrite, malachiite, and chrysocolla. In one part of the mine Sterry Hunt observed some layers of a green earth-like substance which, during the last few years, has yielded a considerable amount of copper. When dried it has a greenish white colour, and readily crumbles to a powder which, under the microscope, is seen to consist of thin transparent plates mixed with a few quartz grains and some magnetite. Analyses of a pure pecimen gave the following numbers:—

Silicic acid	30·73
Alumina	14·67
Iron peroxide	5·35
Iron protoxide	0·29
Magnesia	18·55
Copper oxide	17·58
Quartz	12·83
	100·00

The oxygen ratios of R O : R_2 O_3 : Si O_2 : H_2 O are 3 : 4 : 6 : 4, from which it appears that the substance, if homogeneous, must be placed among the chlorites.—*Zeitschrift für Krystall. und Mineralogie*, 1877, 495.

Silaonite.—Fernandez and Navia have given this name to a new selenide, which they have found associated with guanajuatite. It occurs massive, has a bluish grey colour, a hardness of $2\frac{3}{4}$, and a density = 6·43—6·45. This new Mexican mineral appears to have the composition indicated by the formula Bi_3 Se. Selenium in small quantities has been found in association with tellurium in the josëite of Brazil.—*Zeitschrift für Krystall. und Mineralogie*, 1877, 499.

Vietinghofite.—Damour has analysed a mineral found by De Lomonossow, on the shores of Lake Baïkal. The new species is without crystalline form, has a dull black colour, a semi-metallic lustre, and a vitreous fracture. Its hardness is 5·5—6·0, and the specific gravity = 5·53. A fragment melts

before the blow-pipe, forming a black non-magnetic mass. The chief constitutents of vietinghofite are: niobic acid, 51·00 per cent.; iron protoxide, 23·00 per cent.; uranium oxide, 8·85 per cent.; yttria, 6·57 per cent.; and manganese protoxide, 2·67 per cent. The new mineral appears therefore, to be a variety of Samarskite.—*Bull. de l'Acad. St. Petersbourg*, xxiii. p. 463.

Touchstone.—Dumas has recently published the results of an analysis of a specimen of touchstone, probably the very specimen examined by Vauquelin. ("Journ. Chim. Pharm.," xxii. p. 426). The silica present amounts to 81·40 per cent. He believes the touchstone to be a variety of fossil wood, a small portion of the woody tissue of which has not been replaced by silica. Certain specimens from the Alps yield on ignition an ash which consists of silica only; they still retain, however, sufficient evidence of structure to allow of the determination of the genus whence they are derived. A microscopic examination of sections of touchstone by Regnault has shown that in some cases the organic matter present consists of a variety of bitumen resulting from the decomposition of the tissues of the original wood; the intense black colour of that substance, as it fills the cell-walls and spaces once occupied by fibrous structure, renders the form and details of the cellular portion apparent.

Meteorites.—Professor Tschermak, of Vienna, has issued a short notice of the important additions made, down to the end of September, 1877, to the collection of meteorites under his care. During the last five years stones from twelve, and irons from eight, new localities have been added. The remaining (fourth) fragment of the giant stone of Knyahinya has been acquired by purchase, and it now weighs, in its entirety, 293 kilog. A large mass of, iron, weighing 198 kilog., from the Bolson de Mapini, Cohahuila, Mexico, has likewise been acquired. The total number of falls now represented is 308; in 1819 the number was 36; in 1843 it rose to 94; in 1859 it was 176, and in 1868 it attained 244. Since 1869 Professor Tschermak has added specimens of 64 falls, previously not represented, to the collection; and the total weight of meteoric matter has during the interval been increased from 570 kilog. to 1025 kilog. The most recent aerolitic showers, of which specimens have been secured, are those which occurred at Iowa City (Amana), Iowa, February 12, 1875; and Zsadany, Temeser Comitat, Hungary, March 31, 1875; and the last new meteoric iron comes from Nenntmannsdorf, Pirna, Saxony, and bears the date 1872.

PHYSICS.

Magnetism of Nickel.—M. H. Wild has investigated the magnetic properties of pure nickel, and comes to the following conclusions. Unlike pure (soft) iron, pure nickel acquires a considerable amount of permanent magnetism, but its maximum is only from one-third to one-half of the permanent magnetism acquired by hard steel, according to the goodness of the latter. The magnetism remaining in nickel after the cessation of the magnetizing influence is less permanent than in well-hardened steel; and the gradual loss of magnetism by lapse of time, as also by warming and cooling, is

comparatively greater in nickel than in hard steel, even when it is brought, like the steel, to a certain state of permanence by repeated heating and cooling. In this condition, the temperature-coefficient of a nickel-magnet is little greater than that of well-hardened steel. The temporary magnetism acquired by pure nickel is about double its permanent magnetic moment, half the temporary magnetism acquired by hard steel, and one-fourth of that of soft iron.—(*Bull. Acad. Sci. de St. Petersb.* tome xxiv., No. 1, p. 1.)

ZOOLOGY.

The Rhinoceroses.—Professor Brandt has communicated to the Academy of Sciences of St. Petersburg a synopsis of the family Rhinocerotidæ. He divides the family into three subfamilies, namely:—

I. *Thysanodontes* or *Hippodontes*, with rudimentary incisors, and molars resembling those of the horse. It includes the single fossil genus *Elasmotherium*.

II. *Aulonodontes*, the typical rhinoceroses, destitute of canines and frequently with rudimentary incisors, furnished with molars with several roots, and with the crowns traversed by rather oblique transverse furrows. These are usually horned, and include the following genera:—

1. Atelodus, Pomel, with the subgenera *Tichorhinus*, Brandt (*antiquitatis* and *Merckii*), *Mesorhinoceros*, Brandt (*leptorhinus*), *Colodus*, Brandt, (*pachygnathus*), and *Colobognathus*, Brandt (*bicornis* and *simus*).
2. Dyhoplus, Brandt (*Schleiermacheri* and [?] *sansaniensis*).
3. Ceratorhinus, Gray (*sumatrensis*, *lasiotis*, and *cucullatus*).
4. Rhinoceros, Gray (*sondaicus*, *unicornis* and *inermis*).
5. Aceratherium, Kaup (*incisivum*, *minutum* and *Goldfussii*).

III. *Palæotheriodontes* with six incisors and two canines in each jaw, and molars like those of the second subfamily. Includes only the fossil genus *Hyracodon*, Leidy.—*Bull. Acad. Sci. de St. Petersb.*, tome xxiv., No. 1, p. 167.

A Zoological Laboratory for the Channel Islands.—We learn that Mr. W. Saville Kent is now endeavouring to establish in Jersey, by the agency of a Limited Liability Company, a Museum and Laboratory of Marine Zoology and Institute of Pisciculture. He proposes to realize in Jersey the advantages at present furnished only by the Neapolitan Marine Aquarium and Zoological Station; and at the same time to supplement the resources of the establishment, and promote the study of the animal inhabitants of the sea, by supplying zoologists in England and elsewhere with specimens of the creatures forming the rich and varied fauna of the shores of the Channel Islands. Scientific pisciculture is also to constitute one of the leading objects of the "Society." Such an undertaking, if it can be carried out, cannot but furnish a new attraction to the numerous visitors to Jersey, and must exercise a beneficial influence on the study of marine natural history in this country, and we most heartily wish it success. Particulars of the proposed undertaking will be found in "Nature" for December 6, 1877.

The Tape-worms of the Shrews.—In the number of this Review for July

1877, p. 324, we gave a brief account of a new form of vesicular parasite (*Staphylocystis biliarius*), detected by M. Villot, adhering to the biliary vessels of *Glomeris*. That gentleman has since described a second species under the name of *Staphylocystis micracanthus*, from its hooklets being smaller than those of the first-named form. The singularity of the habitat of these larval Cestoids is now explained by the discovery made by M. Villot, that they are the scolices of Tænias infesting the intestines of the Shrews, as these small mammals will undoubtedly devour any specimens of *Glomeris* that may fall in their way. According to Dujardin, our common Shrew (*Sarex vulgaris*) harbours a Tape-worm named *Tænia scutigera*, whilst the little Garden Shrew (*Sarex araneus*) isinfested by three forms of these parasites, namely, *Tænia scalaris*, *tiara*, and *pistillum*. M. Villot regards the distinction between *T. scutigera* and *scalaris* as founded in error, and thinks that these two forms constitute probably a single species, which would therefore infest both species of Shrews; of this species his *Staphylocystis biliarius* is probably the scolex. *S. micracanthus* he refers without hesitation in the same capacity to *Tænia pistillum*.

The history of these parasites is therefore as follows, as interpreted by M. Villot:—The adult progrottids, or so-called joints of the full-grown Tape-worm, loaded with their cargo of eggs, issue from the intestine of the Shrew and remain on the damp ground until some wandering *Glomeris*, either by accident or design, takes them into his stomach, probably along with the decayed vegetable matters on which the Myriopod habitually feeds. Once in the stomach of a suitable host, the young embryos of the parasite will make their way into the biliary ducts, which open near the commencement of the animal's intestine, and, travelling along these for some distance by the agency of their stylets, will finally traverse the walls of those vessels to take up their abode in the midst of the fatty tissue. Here they lose their embryonic stylets, which are no longer of service to them, pass to the vesicular state, undergo proliferous multiplication, and become scolices. A Shrew meeting with one of these Myriopods would eat him up without hesitation, and thus introduce into his own stomach perhaps a hundred or more scolices, which would at once attach themselves to the intestine and bud into perfect Tape-worms.—*Comptes rendus*, November 19, 1877.

Purple Oysters.—It appears that last autumn the oysters in the Bay of Arcachon acquired a very remarkable violet colour. M. Descoust finds that this coloration is due to the presence in the oyster-basin of great quantities of a Floridean Seaweed, *Rhytiphlœa tinctoria*, the spores of which are very highly coloured. He finds that the colouring matter of these spores is assimilated by the oysters, and retained by them, more or less modified, in the lobes of the mantle and the branchiæ, and that they cannot get rid of it unless the water of the oyster-parks is sufficiently diluted by rains. He says that last summer, and especially during the months of June, July, and August, the drought was extreme all about the basin of Arcachon; hence the oysters became gorged with the colouring matter, the water of the parks not being sufficiently diluted to dissolve the latter.—*Comptes rendus*, November 19, 1877.

The Great Newfoundland Calamaries.—Prof. Verrill has lately had an opportunity of examining a fine example of one of these gigantic Cepha-

lopods, which enables him to correct some of his previous notions about them. The specimen, which was alive and nearly perfect when found, was cast ashore, after a severe gale, at Catalina, Trinity Bay, Newfoundland, on 24th September last. After being exhibited for two or three days at St. John's, it was sent in brine to New York, and exhibited in a tank full of alcohol at the Aquarium in that city.

Prof. Verrill says ("Amer. Journ. Sci.," November 1877, p. 425): "Although somewhat mutilated, and not in a very good state of preservation when received, it is of great interest, being without doubt the largest and best specimen ever preserved. It proves to be *Architeuthis princeps*, formerly described by me from the jaws alone, in this Journal ('Amer. Journ. Sci.,' vol. ix. p. 181). The jaws agree well in form and colour with the large pair there figured, and are fully equal to them in size, being apparently larger in proportion to the body than in *A. monachus*; so that my estimate of the probable size of the body of the former specimen was much too great. The Catalina specimen when fresh was 9·5 feet from tip of tail to base of arms; circumference of body 7 feet; length of tentacular arms 30 feet; length of longest sessile arms (ventral ones) 11 feet; circumference at base 17 inches; length of upper mandible 5·25 inches; diameter of large suckers 1 inch; diameter of eye-sockets 8 inches. (The eyes were destroyed by the captors.) It agrees in general appearance with *A. monachus*, but the caudal fin is broader, and less acutely pointed; it was 2 feet and 9 inches broad when fresh, and broadly sagittate in form. The rims of the large suckers are white, with very acutely-serrate margins; and the small smooth-rimmed suckers, with their accompanying tubercles, are distantly scattered along most of the inner face of the tentacular arms, the last ones noticed being 19 feet from the tips. The sessile arms present considerable disparity in length and size, the dorsal ones being somewhat shorter and smaller than the others; the serrations are smaller on the inner than on the outer edge of the suckers."—Although Professor Verrill has found himself compelled, on better acquaintance, to reduce considerably the size of his monster (which he formerly thought to be 19 feet long in the body), the measurements here given leave him still a sufficiently formidable "Devil-fish," and it is probably with a view to his suitable appearance in that character that, as we are told by Professor Verrill, the animal has been "prepared" by a taxidermist, "who has inserted two large, round, red eyes close together on the top of the head!"

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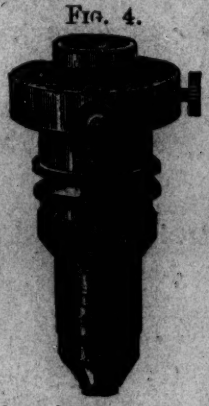

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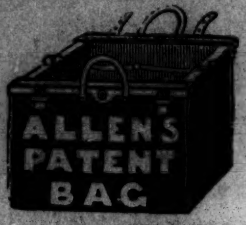

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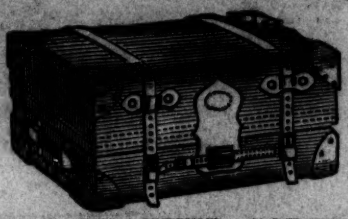

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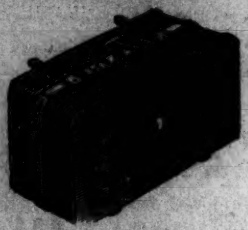

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